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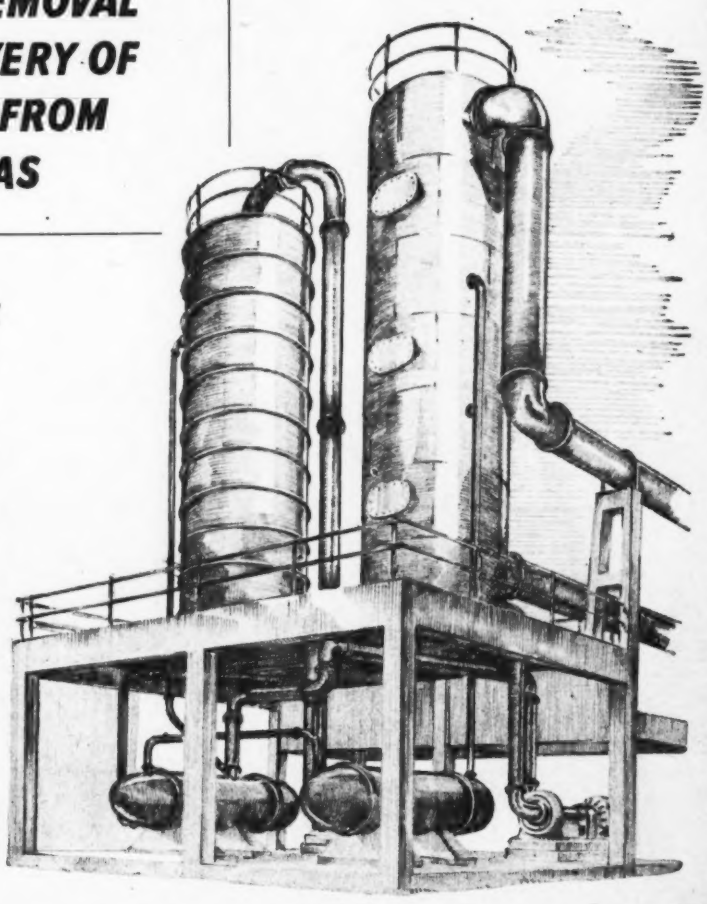

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CONTENTS

		PAGE
Review		1
The Sulphur Industry of Sweden		3
Prices and Trends		12
United States Sulphur		15
Sulphur in Mexico		19
United Kingdom Sulphur		23
Natural Gas in Canada		26
Sulphuric Acid Production by the Petersen System		30
Explosion Prevention by the Graviner System		32
Company Reports:		
Freeport Sulphur Company		34
Duval Sulphur and Potash Company		36
CURRENT EVENTS:		
SULPHUR PRODUCTION AND CONSUMPTION:		
United Kingdom	Brimstone Acid Plant	36
Australia	Plant Modernization	36
Canada	Sulphur Recovery at Nickel Smelter	37
	New Ore Concentration Plant	37
	Nickel Smelter Project	37
U.S.A.	Texas Gulf Sulphur Board Changes	38
	Sulphuric Acid for Uranium	38
	New Loading Facilities	38
	New Fertilizer Plant	39
France	Sulphur Recovery from Natural Gas	39
Japan	By-Product Sulphuric Acid at Flash Smelter	39
Puerto Rico	Establishment of Basic Chemical Industry	40
INDUSTRIES ASSOCIATED AND DEPENDENT ON SULPHUR:		
United Kingdom	Desulphurisation of Coking Plant	40
Australia	Fluidized Roasting of Copper Concentrates	41
India	Heavy Chemicals Expansion	41
Trinidad	Acid and Oil Refinery	42
South Africa	New Uranium Producer	42
Holland	Brimstone Acid for Fertilizers	43
Finland	Expansion of Pulp Production Capacity	43
Israel	Establishment of Rayon Industry	43
U.S.S.R.	Sulphuric Acid/Fertilizer Production	43

INDEX TO ADVERTISERS:

Biddle Sawyer & Co., Ltd.	iii	*Graviner Manufacturing Co. Ltd.*	v
British LaBour Pump Co. Ltd.	xi	*Gulf Sulphur Corporation*	ix
Chemical Construction (G.B.) Ltd.	vii	*Haughton's Metallic Co., Ltd.*	v
Courtaulds Ltd.	x	*Huntingdon, Heberlein & Co. Ltd.*	vi
Duval Sulphur & Potash Co.	ix	*Jefferson Lake Sulphur Co.*	iv
Economist Intelligence Unit	ix	*Pan American Sulphur Co.*	iv
Ente Zolfi Italiani	v	*Simon-Carves Ltd.*	xii
Fisons Ltd.	i	*The Coppée Co. (G.B.) Ltd.*	ii
Freeport Sulphur Co.	iv	*Verlag Handelsblatt G.M.B.H.*	viii

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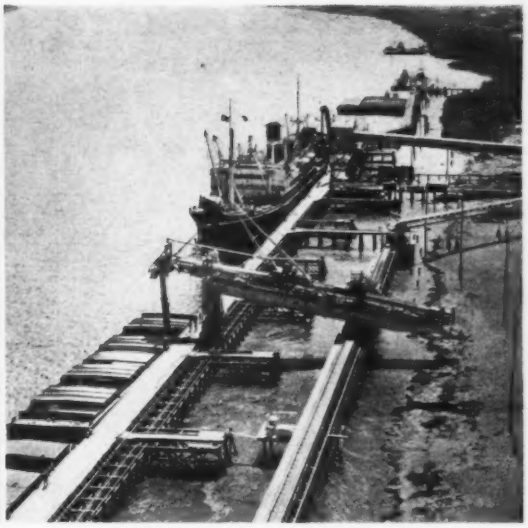

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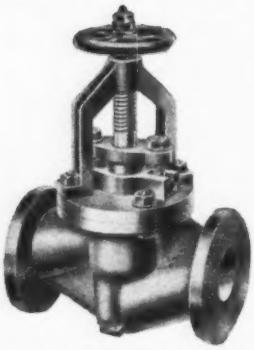

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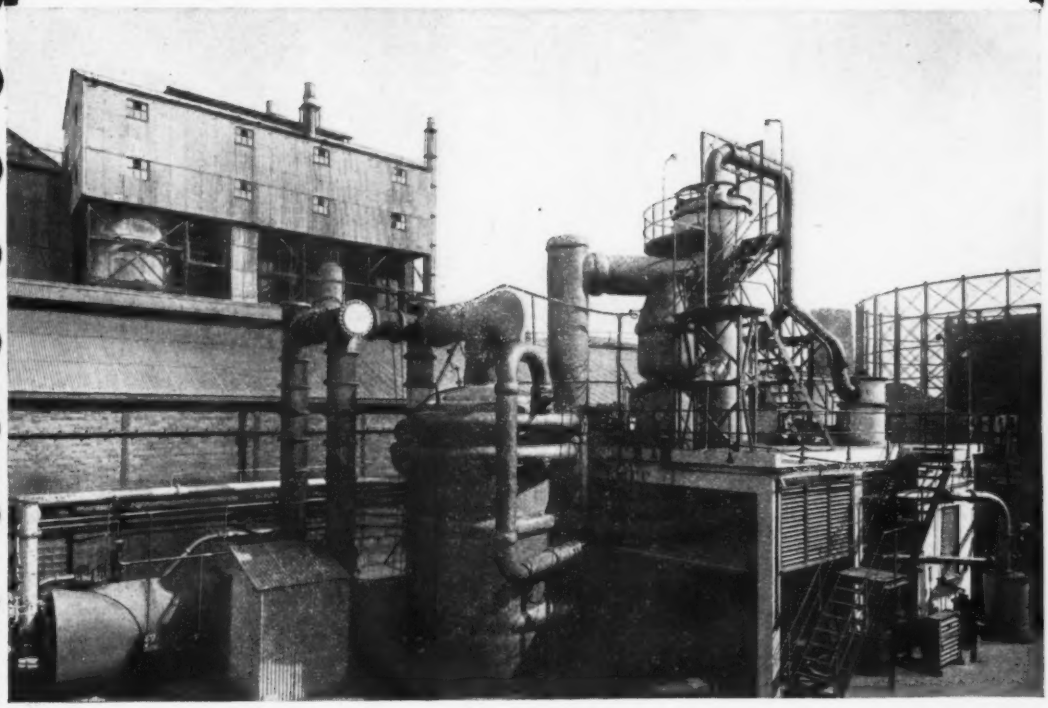

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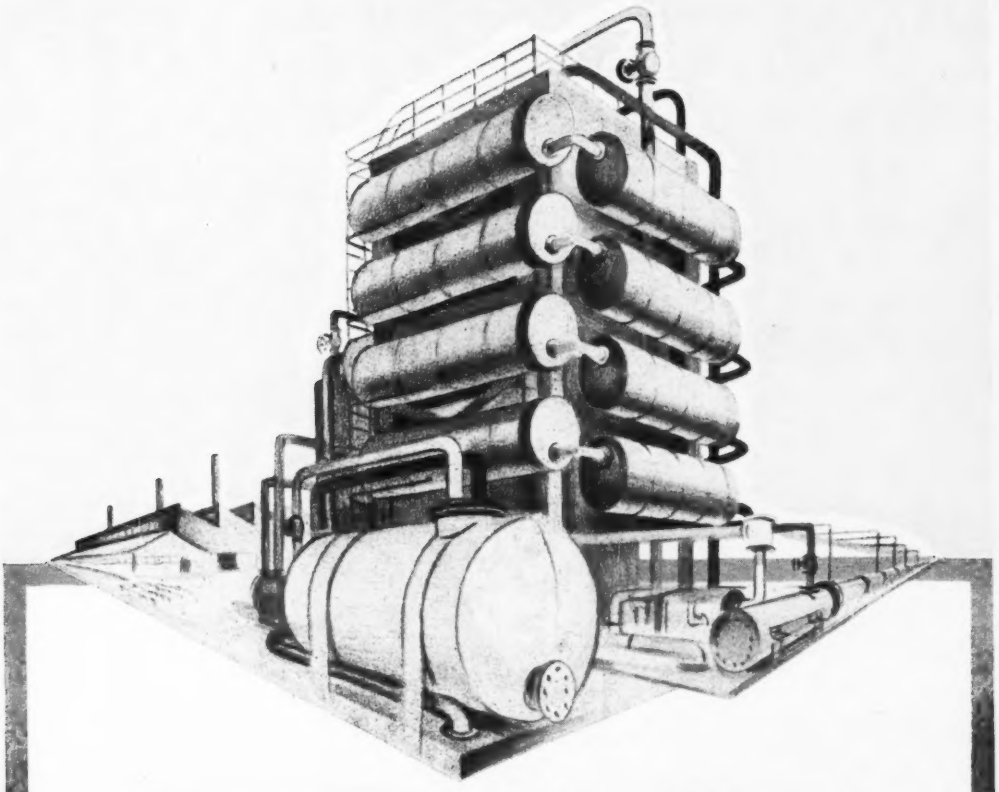

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Review

THE Sulphur Industry of Sweden fully reflects the progressive character of the economy which is one of the most prosperous in Europe. It derives its strength from the intensive use of a limited number of natural resources, notably water power, iron and forest products. The wood pulp industry, which is a major factor in Sweden's industrial employment and its foreign trade, having represented in 1955 over one-fifth of the value of all exports, uses 180,000 tons sulphur annually—about 53% of total usage. Sulphuric acid manufacture accounts for 43% and the needs of the viscose rayon industry make up the balance to 330,000 metric tons. Indigenous supplies in the form of recovered brimstone, pyrites concentrates and by-product sulphuric acid meet about two-thirds of the total needs and also satisfy small export deliveries of pyrites and sulphuric acid. The decisive factors in the supply picture are the mixed sulphide ore mining, concentrating and smelting activities of Bolidens Gruvaktiebolag, one of the leading mining and metallurgical enterprises in Europe. Norwegian cupreous pyrites, prior to 1938 the dominant source of supply, continue to meet the needs of the acid plants and also the residues treatment installations of Reymersholms Gamla Industri A/B which produce cement copper, iron briquettes and chemicals.

Sweden's brimstone needs are met in part by recovery from shale oil retort gases, but mainly by imports from Norway, Italy, Chile and, more recently, Mexico. The strong competitive position of indigenous sulphur supplies gives the industry great stability which is enhanced by the essential cupreous pyrites imports. The rising sulphur needs of the country which may include before long sizeable acid requirements for uranium ore leaching are likely to be sought in the form of brimstone from overseas sources of supply although envisaged expansion of sulphur recovery facilities is likely to close the supply gap before 1960.

Practically all sectors of the **United States Sulphur Industry** attained record results in 1956. The outstanding achievement was Frasch sulphur output of 6,427,229 tons which together with peak recovered brimstone production occasioned an increase of stocks by 750,000 tons to 4.1 million tons. The domestic market, under the stimulus of continued high demand for sulphuric acid output and 10% increase in non-acid needs, also expanded to 5.8 million tons. This was met in the first place by increased supplies of recovered brimstone, by-product sulphuric acid, pyrites and notably 240,000 tons imported Mexican sulphur, but Frasch sulphur deliveries to the home market declined 118,000 tons. An increase in Frasch sulphur exports of 50,000 tons resulted in peak deliveries of 1.65 million tons. This year only twelve Frasch domes are active but the two major companies' development programme promise to enter two domes not later than 1958 and at least one major off-shore project before 1960. In contrast with this imminent addition to capacity is the probability of the need for downward revision of schedules to avoid excessive stock accumulations. In spite of this embarassment by the severe competition of recovered and imported sulphur supplies, U.S. Frasch industry is expected to meet this year at least one-third of total world supplies, two-thirds of U.S. supplies and three-quarters of world brimstone trade.

The Sulphur Industry of Mexico, having achieved in 1956 a peak production of 775,000 tons and record exports of 481,000 tons, is confident of further significant expansion in 1957. As is customary in a young industry success and failure occurred side by side. Pan-American Sulphur Company with outstanding development and production record accounted for the bulk of output and deliveries, while Mexican Gulf Sulphur Company, the first Frasch sulphur producer in Mexico, virtually ceased to operate due to exhaustion of the San Cristobal dome. In the meantime Gulf Sulphur Corporation, under new ownership, successfully started to produce and export. This year Texas Gulf Sulphur Company started operations on a small scale. Texas International Sulphur Co. initiated the construction of a 1,000 tons per day Frasch sulphur plant at one dome and, in conjunction with Fish Engineering Company, assessed the possibilities of exploiting another dome on its vast concession area with the aid of the idle Frasch plant of Mexican

Gulf Sulphur Company. With output plans of one million tons of predominantly filtered brimstone and projected exports of over three-quarter million the Mexican sulphur industry can expect to continue playing an important part in the healthily booming economy.

The Sulphur Industry of the United Kingdom expanded its activities in 1956, in contrast with the absence of growth in general industrial activity. Consumption of 1.11 million tons sulphur was 4½% greater than in 1955, mainly as the result of the demands of the sulphuric acid industry, while indigenous production rose to 593,000 tons. In the first year free of control since 1939, a new pattern of sulphur consumption for acid manufacture emerged based on peak use of anhydrite and more intensive use of brimstone at the expense of pyrites, and to a lesser extent spent oxide usage. Brimstone consumption for non-acid uses, determined principally by the rayon and rubber industries, and anhydrite use in direct sulphate of ammonia production, remained practically unchanged and expanded little more than 1%.

In view of the ready availability of low cost brimstone the imminent expansion of sulphuric acid capacity—2.79 million tons (100% H_2SO_4) in 1956—is almost exclusively based on this raw material. In 1957 total consumption is expected to rise about 5%, again mainly as a result of sulphuric acid expansion and to continue the trend of last year's raw materials use pattern.

By the end of the year the availability of **Natural Gas in Canada** will have changed from a local to a national source of cheap power. The provision of adequate capital by private and public finance to the extent of $1,300 million, to Westcoast Transmission Company and Trans-Canada Pipelines Company, has initiated the construction of a 650-mile pipleline from the Peace River area, south through British Columbia to the U.S. Border and from the heart of Alberta to Montreal in the east.

A sizeable proportion of crude gas supplies will give rise, at the cleaning stage, to H_2S extraction and entail sulphur recovery. Gas is due to start flowing in November 1957 and is likely to average daily 2,000 million cubic feet by 1959/60 when concurrent sulphur recovery may total at least one-half million tons per annum. The profitable sulphur disposal outside the gas field area will depend on transport cost to consuming centres in Eastern Canada, U.S.A. and overseas export destinations.

The danger of explosion in sulphur and pyrites grinding is ever present and special precautions are essential. Relevant points are discussed in conjunction with the Graviner system of **Explosion Prevention.**

The Petersen system of sulphuric acid plant construction is world renowned, especially the tower process whereby many an obsolescent chamber acid installation has been brought up to modern and efficient standards. This review is concerned with the contact installations and their particular ability to deal with SO_2 from sulphide ores and other low grade sulphurous raw materials.

World prices of brimstone have remained stable although the volume of output and the increase of stocks to 4¾ million metric tons have further weakened the market. U.S. Frasch producers charge $27 to $28 per ton f.o.b. in home and export markets while Mexican Frasch sulphur prices range from $24 to $26.50 per ton f.o.b. European pyrites are sold at £4 10s.-£5 per metric ton f.o.b. The recent decline in sea freights is reflected in a reduction of up to 10% of the landed cost of brimstone and pyrites in U.K. and Europe.

World supplies continue expanding faster than demand. The impact of recovered sulphur on local markets is increasingly felt and, in view of the volume of planned brimstone output in France, Canada and Middle East, these sources of supply will also affect world trade toward the end of next year. Thus the continued productivity of the major established domes may prove an increasing embarrassment to U.S. Frasch sulphur producers whose new dome developments are progressing rapidly.

THE SULPHUR INDUSTRY OF SWEDEN

General

ONE of the most prosperous and progressive countries in the world, Sweden owes its successful industrial development to the intensive exploitation of the limited number of her natural resources. The growth since the end of the last century of Sweden's forest industries, which together with iron, steel and water power can be said to represent the foundation of her modern prosperity, has in large measure been conditioned by the manufacture of chemical pulp which in turn is closely bound up with the development of the sulphur industry. Even so sulphur, in the form of brimstone and pyrites, used in the production of sulphite pulp remained predominantly an imported commodity until after the 1939-45 war and until then Sweden looked to its Scandinavian neighbour and to Spain for the bulk of sulphur supplies.

Stora Kopparbergs Bergslags A/B, one of the oldest copper producers in the country and indeed the very source of Sweden's dominating hold on Europe's copper market in the 16th century, always provided a relatively small indigenous supply of pyrites but the emancipation from foreign pyrites dependence was only achieved with the development, which started in 1929, of Bolidens Gruv A/B into one of Europe's prominent non-ferrous ore mining, processing and metal smelting concerns. Although their role is curtailed Norwegian pyrites supplies which are predominantly in the form of cupreous ore, still play an important part. They meet the sulphur needs of a sizeable proportion of Sweden's sulphuric acid supplies and at the same time provide the residues intake of Reymersholms Gamla Industri A/B's famous cinders treatment plant at Helsingbörg which owes its origin to the common interests of the two industries.

Notwithstanding the importance of pyrites as a major source of sulphur for Sweden's variety of essential requirements, the use of brimstone has been prominent in the past and is increasing notably in the manufacture of sulphite lye, pulp bleaching and rayon manufacture and more recently also in sulphuric acid production. Its indigenous production by recovery is an integral part of Sweden's shale oil industry which itself helps to overcome one of the handicaps of Sweden's chemical industry whose growth has been impeded by the lack of the conventional basic raw materials such as coal, oil and salt. This production of liquid and gaseous petroleum products under State auspices at Kvarntorp also facilitates synthetic ammonia manufacture for industrial and fertilizer use, although most of Sweden's domestic nitrogenous fertilizer supplies come from the electro-chemical industry.

Sulphur consumption in various forms totals 330,000 tons* annually of which about 100,000 tons is in the form of brimstone, 220,000 tons sulphur in the form of pyrites and about 7,000 tons sulphur as by-product sulphuric acid. The pulp industry claims

* All quantities are given in metric tons.

nearly three-fifths of this tonnage for SO_2 and bleaching, sulphuric acid manufacture accounts for just over two-fifths and the rayon industry, using about 8,000 tons for CS_2 manufacture, represents the balance. Sulphuric acid production, including about 40,000 tons of by-product acid totals over 400,000 tons per annum which is provided by five producers of whom two are exclusively fertilizer manufacturers. Of the country's total sulphur needs a little over one-third is imported, Norway being the principal supplier with annual deliveries of about 40,000 tons brimstone and 50,000 tons sulphur in pyrites. Italy, Chile and Mexico have in recent years contributed to the balance of brimstone imports, which in 1956 totalled 79,010 tons, whereas Cuban cupreous ore filled a small part of the pyrites imports needs. Domestic production is stable at about 215,000 tons sulphur in pyrites, 30,000 tons recovered brimstone and 15,000 tons sulphur in by-product sulphuric acid from Bolidens smelter gases. Token pyrites exports to Central Europe, Holland and the United Kingdom and shipments of about one-half of the by-product acid output to Germany represent Sweden's sole contributions to foreign sulphur needs. The outstanding quality of Bolidens pyrites, which yield an iron residue of high purity in great demand by blast furnaces, especially in Germany, extends the Swedish sulphur industry's orbit of influence and enhances its competitive position.

PRODUCTION

Arising in the form of brimstone, pyrites or sulphuric acid, Sweden's sulphur output is wholly a by-product of the primary oil refining, ore benefication and metallurgical operations. This outstanding feature imparts significant advantages to the industry in that it provides relatively low cost products which can readily meet competition, although there is the limitation that beyond certain levels of production which are governed by the primary products, Sweden has to look abroad for its sulphur supplies.

Pyrites

There are two producers, Bolidens Gruv A/B and Stora Kopparbergs Bergslags A/B, whose combined output, each the result of the treatment of non-ferrous metal sulphide ores, has since 1948 been fairly constant at about 400,000 tons per annum pyrites concentrates. Following last year's small expansion of Bolidens output it is now inticipated that

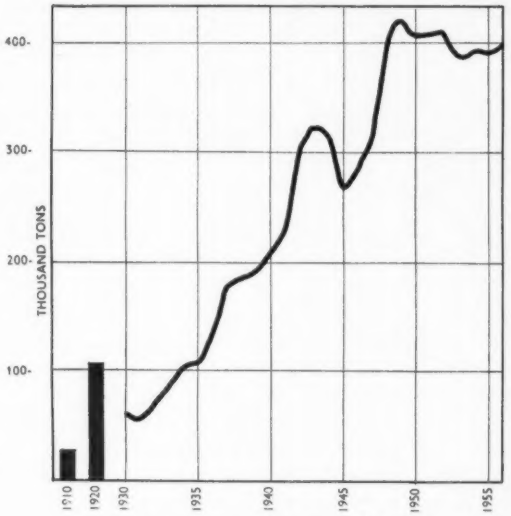


Fig. 1. Pyrites Production 1910-1956.

for the next three-five years an annual output of 420,000-450,000 tons pyrites concentrates containing 200,000-225,000 tons sulphur will become available.

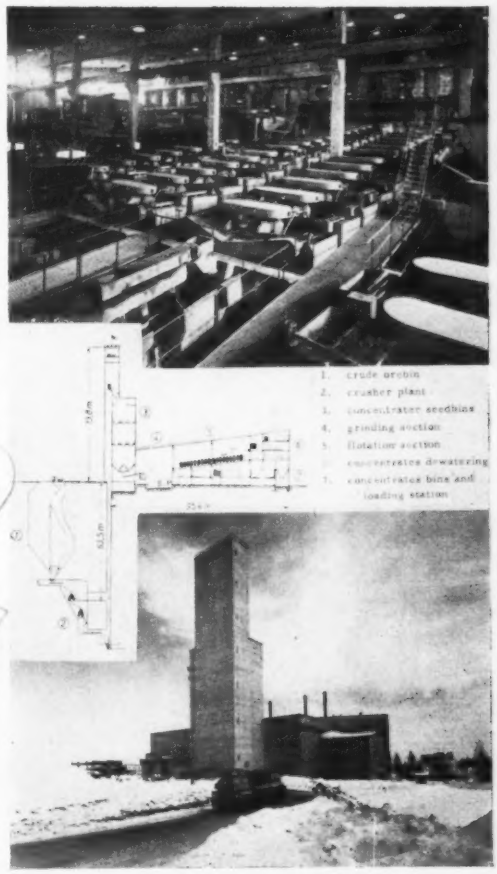
Bolidens Gruvaktiebolag:—The company's activity is centred around a number of sulphide ore deposits, mainly concentrated in northern Sweden—latitude 65° and includes mining, smelting and refining of metals and the manufacture of chemicals. Its mines in Norrland are, as regards both organisation and geographical location, grouped around three central concentration plants situated at Boliden, Kristineberg and Laisvall. The smelters for copper and lead and the chemical factories are at Rönnskär, where the river Skellefte runs into the Gulf of Bothnia. During the roasting and smelting processes a number of by-products are obtained and these are processed in a special works. The various products for 1955 were as follows:–

Concentrates	
Iron Pyrites	340,000 tons
Zinc	60,000 tons
Metals	
Copper (electrolytic)	31,900 tons
Lead (refined)	21,400 tons
Gold	3,800 kg.
Silver	72,200 kg.
Arsenic products	12,500 tons
Selenium	63 tons
Sulphuric Acid	41,000 tons

Boliden is the leading producer of non-ferrous metals in Sweden, the world's largest producer of arsenic and Europe's largest producer of selenium. The company plays an important role in the economic life of Norrland employing about 4,500 people; the present annual turnover is in the region of £20 million. It has achieved this position in less than thirty years and contributory factors have been intensive research in the fields of prospecting, ore dressing, metallurgy and chemistry. The company is an undisputed leader in modern prospecting technique which put into practice has led to the discovery of ore deposits on a sufficently large scale to result in a continuous expansion of known reserves despite rapidly rising ore extraction.

The production of pyrites concentrates is based on ores with a sulphur content between 20% and 40% and varying amounts of copper, lead and zinc. The deposits are located within a relatively restricted area bordering the River Skellefte where the following mines are currently producing crude ore for the production of iron pyrites: Boliden, Langsele, Renström, Östra Högkulla, Kristineberg, Rävliden and Rudtjebäcken. In all cases the ores are very finely disseminated and in order that their non-ferrous metal content can be extracted economically they have to be subjected to concentration. The processing of ores containing iron pyrites has been centralised in recent years in a new concentration plant at Boliden with an annual capacity of 500,000-600,000 tons and also in a concentration plant at Kristineberg. The latter plant has recently been extended and modernised to handle 600,000 tons of ore per annum.

The design of the concentration plant at Boliden, which was taken into operation in 1953, is based on the company's wide experience of installations of this kind and it has been used as the model for a number of sulphide concentration plants subsequently erected in northern Europe. The plant contains two parallel operating sections and, as a result, it is always possible to concentrate two different ores at the same time. The processing method to which the ore is subjected is shown in the flow diagram. After crushing in the plant underground the ore is transported by skip-hoisting to high-level bins above ground. The ore is then fed into a mill in which it is ground to the required grain size, generally 75-90% minus 270 mesh. The various minerals are separated by selective flotation in high-effeciency apparatus of the company's own design. Copper concentrates, lead concentrates, zinc concentrates and pyrites concentrates are extracted in that order. The composition of



General view of the concentration plant at Boliden and flotation sections. The flow diagram shows the layout of the plant.

the ores is of such a special and complicated nature, that the requirements for effective separation during the individual flotation stages are necessarily high. Especially great care must be taken to ensure as far as possible that the pyrites concentrates are freed from metallic impurities. The concentrate emerging from the flotation stage is thickened, filtered and dried in direct-fired, current flow drying kilns in which the copper, lead and zinc

concentrates have a final relative moisture content of 2%-3%. The resultant pyrites concentrates have an average sulphur content of about 50% and are relatively fine grained.

The concentration plant at Kristineberg has been in operation since 1940 and is the largest of the company's plants for the production of pyrites concentrates. Since being modernised and extended the plant operates on the same principles as the concentration plant at Boliden. The dried ores from the Kristineberg plant are transported along a ropeway to Boliden, 60 miles away. Together with the ores from the Boliden concentration plant, the concentrates are then transported by rail to Rönnskär, from where they are shipped. Since the port of Rönnskär is blocked by ice for five months of the year provision for storage is necessary and this is done in large roofed sheds. Most of the company's production of pyrites is sold on the domestic market and used by the cellulose and superphosphate industries. A relatively small amount is exported.

Stora Kopparbergs Bergslags A/B:—Based on the occurrence of iron and non-ferrous ores, forest and water power of the Dal Valley in Central Sweden, which the company owns, its present day activities encompass mainly iron—the Domnarfvet works with an annual capacity of 400,000 tons pig iron is the largeset in Scandinavia—pulp and chemicals manufacture; the production of sulphide metal concentrates including pyrites is limited.

The company, the oldest mining enterprise in Sweden, still operates the Falun Mine where copper mining commenced during the twelfth century, and which became internationally important during the Middle Ages. It attained its greatest importance during the seventeenth century, when its copper output dominated the European market. Thereafter Falun's importance as a copper mine declined and output finally ceased in 1921. Pyrites production which started in 1903, reached its peak in 1917 with an output of over 114,000 tons of ore of about 40% sulphur with a low content of copper, zinc and lead; this was consumed, crushed to 5-6mm., as crude ore. During the years 1926 and 1927 the first flotation concentration plant for the extraction of zinc and lead concentrates was built, and this plant has since been enlarged several times. Since 1949 all the ore from the mine and small quantities of ore from older workings is so treated.

At present the crushing mill and silo, and the crushing department of the concentration plant are undergoing modernization and rationalization. Work is also in progress which will result in a more efficient transport system underground and better winding facilities, so that the exploitation of the deposit over the coming decades may be assured. Output is determined largely by the amount of pyrites needed by the company's own chemical plants, and from a normal annual production of approximately 130,000 metric tons ore of 26% S, 4.5% Zn, 1.5% Pb and 0.3% Cu the following concentrates quantities are obtained:

52,000 metric tons pyrite concentrate with 46% S
9,500 metric tons zinc concentrate with 49% Zn
2,500 metric tons lead concentrate with 49% Pb
2,000 metric tons Copper concentrate with 13% Cu

Zinc and lead concentrate are exported and the copper is sold in Sweden. The whole of the pyrite concentrate is utilised in the company's own plants, which comprise the sulphuric acid works at Falun and Skutskar, and at the sulphite mills at Kvarnsveden and Skutskar. A gradual expansion of mine output, in keeping with the company's rising sulphur needs is foreseen.

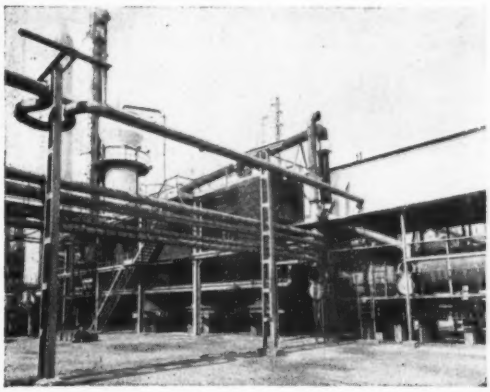
Brimstone

Although in the late thirties, Bolidens Gruv A/B engaged in the recovery of the SO_2 content of the Rönnskär smelter gases and produced elemental sulphur by the I.C.I./Bolidens process, these operations, whilst yielding up to 11,000 tons annually for four years, were discontinued as they proved uneconomical. The exploitation of the country's shale oil deposit by Svenska Skifferolje A/B which, primarily prompted by the war-time oil supply difficulties, started in 1941, proved to be a better and more prolific source of recovered sulphur. Of several major shale deposits in Sweden it was decided to work that situated at Kvarntorp 15 miles south of Orebro. Although its oil yield is said to be low and oil is not of good quality, the shale has a high fixed carbon content—used in steam and power generation — and high sulphur content (6½%-7%) recoverable from the retort gas in the form of H_2S, which seem to compensate for any apparent disadvantages.

The shale is converted in retorts into crude shale oil, gas and ash. The crude shale

oil is refined to produce gasoline and fuel oils. The gas after removal of the hydrogen sulphide content of about 20%, yields butane and propane and is subsequently used for synthetic ammonia production.

The sulphur plant consists of four separate units, three of which have a capacity of 3,000 cubic metres and the fourth of 6,000 cubic metres gas an hour. Each unit consists of an Alkazid plant and a Claus kiln, both



One of four sulphur recovery units at Kvarntorp. Alkazid washtower and Alkazid shipping tower on left.

operating in conventional manner. Crude gas is first washed to remove cyanides, the presence of which might foul the alkazid lye, which absorbs all H_2S contained in the gas stream. This eventually passes through electrofilters which remove any entrained sulphur. The saturated alkazid lye is stripped by steam at 100° C. and the concentrated hydrogen sulphide (90%) and carbon dioxide (10%) mixture is fed to the Claus kiln where, in two-stage combustion and conversion, high purity (min. 99.9%) liquid sulphur is produced. The bulk of the sulphur output is granulated, some is allowed to solidify in vats; delivery to Swedish industry is in the form of granules, lumps and powder. Present output is 30,000 tons per annum and official forecasts indicate near capacity output of up to 32,000 tons for this year and next. Although no specific expansion plans have been announced it is believed that research is nearing satisfactory completion which would permit output being raised to 50,000 tons per annum sulphur. Longer term plans for an expansion of operations to yield more oil and 120,000 tons per annum sulphur have been mooted but not as yet planned.

Smelter Gases

Although Bolidens' technique of ore dressing has resulted in the great bulk of the sulphur content of the crude ores being separated in the form of pyrites concentrates, the smelting material delivered to Rönnskär from the mines during the course of a year still contains some 35,000-40,000 tons of sulphur. In order to make use of this sulphur, a plant has been erected in which the sulphur dioxide in the gases produced during the copper and lead smelting processes is turned into sulphuric acid. It was inaugurated at the end of 1953 and, based on the contact method, has a capacity of 35,000-50,000 tons of concentrated acid per annum. Hitherto, only gases from the copper processing plant have been used since the gases from the lead processing plant have too low a content of sulphur dioxide, at least for the present method of production.

The smelter exit gases are piped direct to the sulphuric acid works without passing through an intermediate concentration stage. The total quantity of gas obtained from the roasting and the smelting furnaces and the converters of the copper plant is much greater than that which can be handled by the sulphuric acid works, viz: about 25,000 Nm^3 per hour. Consequently, only the gases, or combinations of gases, giving the greatest concentration of sulphur dioxide at any time are used.

Thus, while the converters are in the stage of finish-blow (about 4 hours a day) only gases from the converter process, with an average content of 5% SO_2 are used. During the remainder of the day roaster gases of a lower concentration (4.5% SO_2) are used as the basic quantity and the gases produced during the converters slag-blow periods (about 2.7% SO_2) are used as admixture. The gas from the smelting furnaces (about 1% SO_2) is used in conjunction with the roaster gases when the conversion process is closed down. In order that the final acid shall be of the required quality the gases are thoroughly cleansed and special attention is given to freeing the gases from any arsenic carried over when roasting concentrates containing this element.

After passing a cooler and an electrostatic precipitator the converter gases are led through the distributor tower. After the corresponding purification and washing in a washing tower, the gases from the smelting and roasting

furnaces are also conveyed to the distribution tower. By means of dampers in the ducts leading to the distribution tower (operated from a control room in the sulphuric acid factory) the flow of gas at any given time can be mixed as desired. The surplus gases are by-passed into the stack. The gases destined for further processing are again washed with water in four series-connected water towers and finally cleaned in a wet EGR.

The further processing of the gases is shown in fig. 2, which gives details of the system used in the production of the sulphuric acid. After drying with sulphuric acid the gases pass through a spray catcher and heat-exchangers in which they are heated by gas from the converters. The conversion to sulphur trioxide takes place in two converters and the converted gas is absorbed in 98% sulphuric acid. In the absorption circuit acid from the drying tower and water are added. The sulphuric acid is continually drawn off to a production store where it is diluted with water to the correct concentration.

The residue of flotation reagents in the concentrates that have not been completely burned during the roasting process result in the acid passing from the drying tower to the absorption circuit being discoloured to some extent. This discolouration is removed by treating the acid with hydrogen peroxide in the production storage tanks. The final 96% acid is pumped from the factory to storage tanks. To allow for the fact that shipping of acid is held up by ice during the winter season, the tanks are large enough to hold 20-30% of the annual production.

The production of sulphuric acid since the start of the Rönnskär plant has been:

	Production (100% H_2SO_4)
1953 (Nov.-Dec.)	2,800 tons
1954	37,400 tons
1955	41,000 tons

The sulphuric acid is sold mainly on the Swedish market and is delivered by tanker, by rail or by road. Part of the production is shipped to the Continent. The Company's own consumption since 1953 has been:—

	Consumption (100% H_2SO_4)
1953	4,600 tons
1954	5,100 tons
1955	6,400 tons

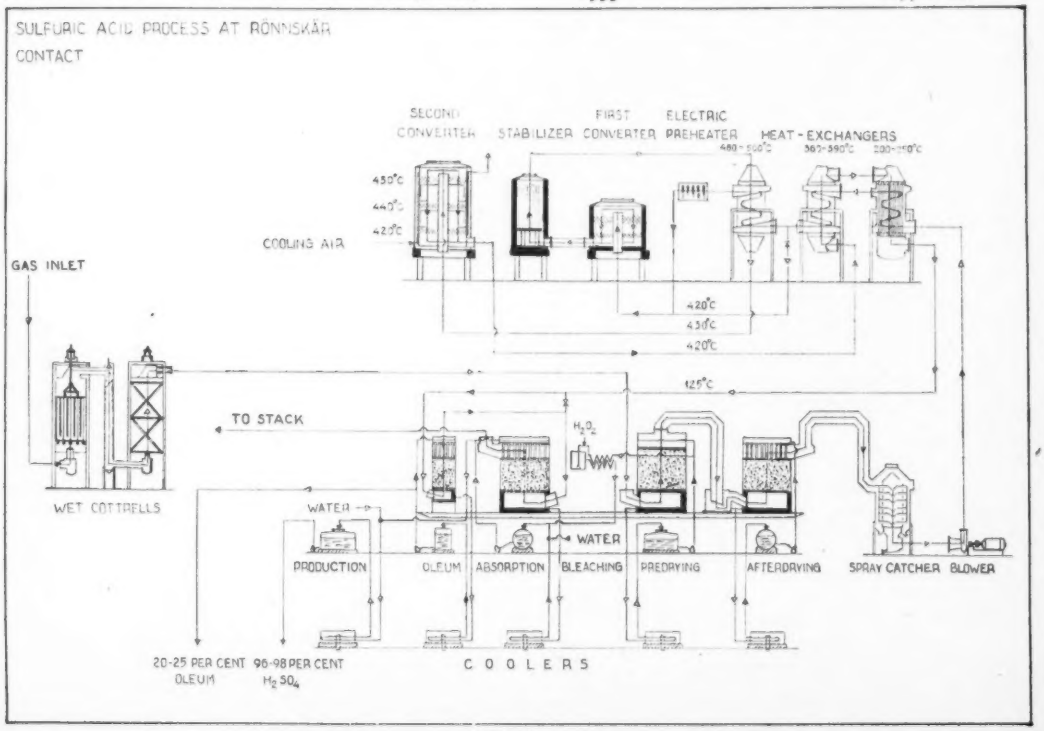


Fig. 2.

CONSUMPTION

Sulphur consumption in Sweden is centred on two industries—sulphite pulp and sulphuric acid—which account for about 53% and 43% of total usage respectively. The balance, apart from 1,000—2,000 tons taken up by a variety of small uses, consumed in the form of CS_2 by the rayon industry, the only major user wholly dependent on brimstone. Domestic pyrites supplies are directed primarily to pulp makers and to the section of the sulphuric acid industry manufacturing fertilisers. Imported pyrites in the form of cupreous ore are almost entirely taken by the sulphuric acid plants of the cinders treatment installations. Hitherto, carbon disulphide needs apart, brimstone was entirely taken up by pulp mills in SO_2 manufacture for lye and bleaching. Last year for the first time a significant tonnage—about 11,000 tons imported from Mexico—was converted to acid.

Sulphite pulp

The importance of the pulp industry to the Swedish economy cannot be over-rated. Representing the highest-valued single export commodity—S.Kr.1,600 million—it accounted for one-fifth of all exports in 1955. Compared with pre-war, the trend is for more pulpwood to be turned into chemical pulp mainly on account of its enhanced value and the need for the best use of timber resources which, in spite of the more favourable prospects than at one time seemed probable, are nearing the limit of economic exploitation.

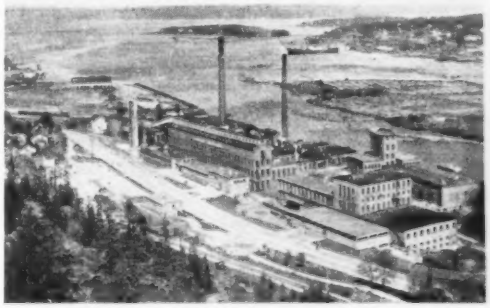
	1937	*1946*	*1955*
Sulphite (Bleached, Unbleached and Dissolving)	1,635,100	1,245,900	1,685,300
Sulphate (Bleached, Unbleached)	1,155,700	821,800	1,327,400
Mechanical	733,700	677,900	900,000
	3,524,500	2,745,000	3,912,700

As shown, sulphite pulp which was perfected and first used commercially in Sweden remains the principal product of the industry. About one-third of output is used domestically in paper, board and viscose rayon manufacture.

The industry's sulphur requirements of about 85,000 tons brimstone and 180,000 tons pyrites are expected to continue expanding. Although the substitution of calcium based pulp liquor by ammonia or magnesia based liquor shows economies in sulphur use, overall economics do not so far point to its wider application.

Almost all the chemical pulp producers are associated in Svenska Cellulosaforeningen. They include 13 major producers whose annual production of sulphite pulp exceeds 40,000 tons—users of more than 4,000 to 4,500 tons sulphur—and 12 smaller producers. Details of some of the major pulp producers, which reflect the general picture of the industry are as follows :—

Stora Kopparbergs Bergslag A/B at the Kvarnsveden and Skutskar pulp mills which have a capacity of 85,000 tons, uses its own Falun pyrites concentrates at an annual rate of about 10,000 tons and also about 3,500



Sulphite pulp mill at Svartvik.

brimstone, of which two-thirds is used in liquid form in the cooking plant and the rest in direct preparation of cooking acid.

Marma Langrörs A/B operates sulphite pulp mills at Vallvik—at an annual rate of 50,000 tons using almost exclusively pyrites—and at Jarpen (18,000 tons) where predominently brimstone is used. Total current usage is about 10,000 tons pyrites and 1,800 tons brimstone.

Wifstavarfs A/B produces about 65,000 tons pulp, using since 1953 exclusively pyrites at an annual rate of 13,000-14,000 tons.

Svenska Cellulosa A/B is the largest producer and operates five sulphite pulp mills, amongst which Svartvik is the largest in the country. Its output of 84,000 tons sulphite pulp in 1955 compares with Essvik 40,700 tons, Ortviken 40,100 tons, Soraker 33,200 tons and

Kramfors 51,800 tons. The company's total sulphur use in 1955 was 8,200 tons brimstone and 38,000 tons pyrites, following five years of almost exclusive pyrites use, at a rate of 50,000-55,000 tons per annum.

Mo och Domsjö A/B an important pulp and chemicals manufacturer, produced 138,000 tons air dry sulphite pulp in 1955, using 30,700 tons Bolidens pyrites concentrates and 2,300 tons brimstone, not including up to 700 tons brimstone for sulphate pulp bleaching. Prior to the sulphur crisis the company used about 14,500 tons sulphur in almost equal parts brimstone and pyrites, while during 1952 and 1953 pyrites became virtually the sole source of sulphur.

Billeruds A/B is one of the largest sulphite pulp producers, operating 4 mills at Billerud, Kyrkebyn, Slottsbron and Jössefors. They are all based on the use of brimstone and together turn out about 125,000 tons pulp.

A/B Iggesunds Bruk at Iggesund produces about 45,000 tons pulp using Boliden pyrites concentrate—at a yearly rate of about 9,000 tons—as the sole source of sulphur.

Uddeholms A/B whose industrial interests extend beyond the forest industries, to mining, steel manufacture, transport and power generation, operate a pulp mill at Skoghall using mostly pyrites as a source of sulphur.

The majority of the smaller pulp mills are believed to use brimstone, such as Hellefors Bruks A/B at Frederiksberg producing 17,850 tons pulp in 1955 and using 1,870 tons brimstone.

Most mills whether or not brimstone is used as the main source for SO_2 manufacture have small rotary brimstone burners as standby equipment. Pyrites users' roasting plant includes multi-hearth furnaces—mostly Lurgi L.C.7 types—Nichols Freeman flash roasters and quite recently Dorr type Fluosolid roasters. With the aid of Bolidens advisory technicians they are reported to have achieved very satisfactory operating results which have much enhanced Bolidens competitive position in this sector of the market.

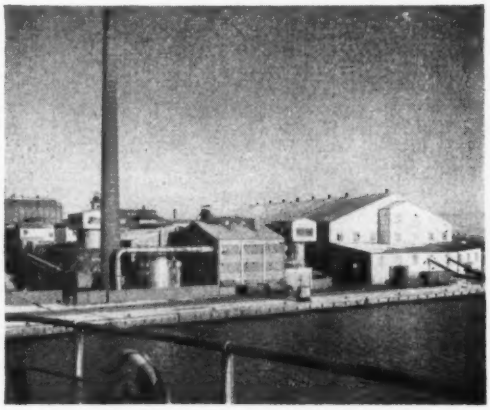
Sulphuric Acid Production

Until 1955 the industry's sulphur needs were wholly met in the form of pyrites and apart from Bolidens by-product acid supplies output has been fairly stable at about 350,000 tons per annum. Last year the first sizeable use of brimstone at Uddevalla is believed to have occasioned an increase of total acid output to about 430,000 tons.

Thousand Tons 100% H_2SO_4

	1950	*1951*	*1952*	*1953*	*1954*	*1955*
Stockholms Superfosfatfabriker	84	5.6	6.8	4.3	1.2	—
Gaddviken Superfosfatfabriks	21.5	21.0	20.7	9.1	16.4	21.9
A/B Förenade Superfosfatfabriker	155.8	164.4	161.0	181.9	189.0	173.0
Stora Kopparbergs Bergslags A/B	53.6	55.5	48.6	52.4	53.1	53.9
Reymersholms Gamla Industri A/B	100.9	100.9	87.6	96.4	104.6	107.0
Bolidens Gruv A/B	—	—	—	2.8	37.4	41.0
	339.9	347.4	324.7	346.9	401.7	396.8

Stockholms Superfosfatfabriker A/B once prominent sulphuric acid/fertilizer manufacturer, ceased production in 1954 when the pyrites based chamber plant, which had met the needs of ammonium sulphate production, was closed down. Nitrogenous fertilizer manufacture by electro-chemical means, ferro-alloys and plastics now engage the company's main interests.



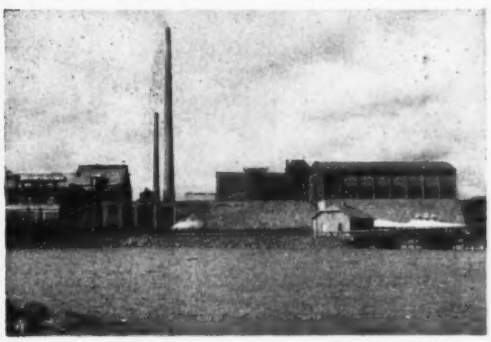
The superphosphate works at Landskrona.

Gäddvikens Superfosfatfabriks A/B formerly associated with Stockholms Superfosfatfabriker A/B who built the Gäddviken plant in 1871, is now a subsidiary of the Swedish Co-operative Society. The entire acid output of 21,000 tons per annum (100% H_2SO_4) is captive for the manufacture of superphosphate, and is based on the use of 16,000 tons

per annum Bolidens concentrate. Four Bracq Moritz furnaces and 6 Herreshoff roasters serve separate lead chamber systems.

A/B Forenade Superfosfatfabriker is the largest phosphatic fertilizer producer in Sweden, operating 3 plants whose output of sulphuric acid is captive for superphosphates manufacture. Enlarged and modified Herreshoff roasters, based on pyrites, serve a contact plant and lead chambers at Landskrona, while at Norrköping similar roasting facilities are used with a Petersen tower. At Uddevalla a contact acid converter, served formerly by a pyrites flash roaster, has since late 1955 the alternative supply from a rotary sulphur burner using Mexican brimstone. The bulk of pyrites are obtained from Bolidens Gruv A/B. The company is closely associated with Reymersholms Gamla Industri A/B mainly on account of joint residues interest dating back to the predominent requisitions of Norwegian cupreous ores.

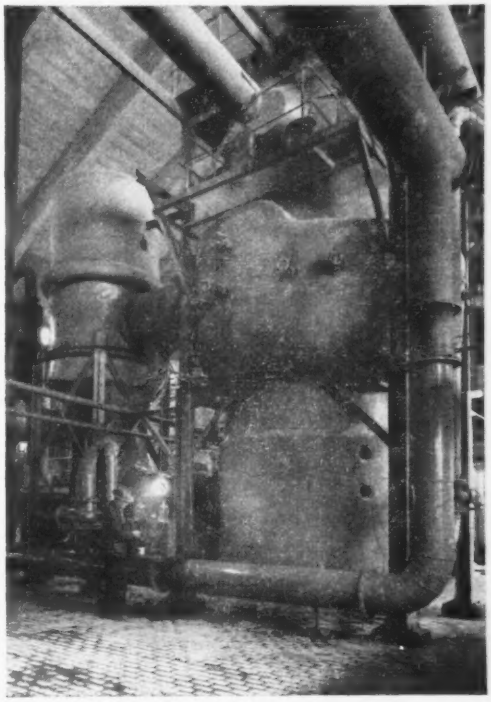
Reymersholms Gamla Industri A/B has sulphuric acid plants at Helsingborg and Oskarshamn. Both are based on the use of Norwegian cupreous pyrites and have contact converters; the one at Helsingborg being served



The sulphuric acid plant at Oskarshamn.

by a B.A.S.F. fluoSolid roaster and the Oskarshamn plant employing enlarged and modified Herreshoff furnaces. The entire output is captive exclusively for chemicals manufacture.

Stora Kopparbergs Bergslag A/B. Operating a small plant at Falun, the company was the first industrial producer of sulphuric acid in Sweden. Two modern vanadium contact plants at Skutskar and Falun now have a combined capacity of 60,000 tons (100% H_2SO_4) based on pyrites concentrates from the company's mine which are roasted in multiple hearth furnaces and flash roasters. A notable feature of the acid plant are the coolers where



Sulphuric acid plant at Falun.

horizontal spiral tubes have replaced overhead sprays. The main product is 96% arsenic free acid, 20-25% and 60-70% oleum is also produced and for chemically pure acid fully automatic glass apparatus is employed. Only 3,000-4,000 tons acid are captive, the rest is sold for chemicals and rayon manufacture.

Sulphuric Acid Consumption

The principal acid use is the manufacture of fertilizers which accounts for about 60% of the output. Phosphatic fertilizer production is at present limited to single superphosphate which after declining 5% last year is expected to expand 10% in the current fertilizer year. Plans for the manufacture of triple superphosphate have been mooted. Acid needs for ammonium sulphate production are small as output in recent years fluctuated between 14,000-18,000 tons.

Other notable users of sulphuric acid are

the textile industry which takes up 10% of output and metallurgical uses which account for a further 5%; the balance of about 110,000 tons meets the requirement mainly of chemicals, explosives and plastics manufacture and also of miscellaneous small users.

Residues

The treatment plants of Reymersholms Gamla Industri A/B at Helsingborg and Oskershamn are concerned with the recovery of the copper and iron contents from cupreous pyrites residues. After leaching, copper accrues in the form of precipitate and iron is turned out in the form of briquettes at Helsingsborg and sinter at Oskershamn.

Conclusion

Since Sweden's indigenous productions of sulphur in various forms are secondary or by-product materials, they tend to lack the flexibility of supply of primary sulphur products but have the advantage of greater competitive scope. In the case of Bolidens pyrites this is partly the result of the high value as blast furnace feed of the pure high iron content residues. This competitive form of indigenous supply imparts great stability to the pattern of consumption which in the case of Sweden is further shielded from fluctuations by the requirement for pyrites imports, cupreous ore, to meet the demand of an important cinders treatment plant. The principal gap in supplies is being met by brimstone imports, mainly from Norway but also from Chile, Italy and Mexico. Sweden's industrial practice is progressive, specialised and based on a recurring capital investment for plant renewal. This trend especially in the chemical industry would be consistent with an expansion in sulphur demand of at least 3%-4% per annum but an increase of this magnitude may be marred by changes in technique of the principal consumer—the sulphite pulp industry. So far the replacement of calcium sulphite liquor by ammonia or magnesia liquor which apart from lower effluent problems, would promote SO_2 recovery, has not generally shown any overriding advantages.

The future level of sulphur demand will be influenced by the extent of the sulphuric acid requirements of the uranium industry the establishment of which, centred round an uranium oxide plant, was announced recently. Pending the determination of the higher level of sulphur recovery from oil shale, which is also one of the potential uranium sources, the continued though modest expansion of brimstone imports from overseas may be expected.

Prices and Trends

WORLD prices of brimstone during the past three months have remained virtually unchanged. This outwardly stable price position masks the progressive statistical weakening of the world market as the volume of competing supplies grows.

U.S. producers continue to base their prices in both home and export markets on $28 per ton f.o.b. for bright sulphur; similarly the discount for off-colour qualities applicable to a proportion of shipments by Texas Gulf Sulphur and Freeport Sulphur Companies remains $1 per ton. Mexican Frasch sulphur prices continue to range from $24-$26.50 per ton f.o.b. Coatzacoalcos. Crude—unfiltered—material which last year represented the bulk of deliveries and on account of which prices tended to be nearer the lower than the upper limit, is expected to be relegated to a minor rôle at prices dipping below $24. For filtered material, which is expected to have carbon content of about 0.3%, and possibly as low as 0.2% for special grades, producers are expected to charge $25.50-$26.50. Pan-American Sulphur Company, which is aiming to expand sales from a soundly established position and on the basis of notable sales and production achievements, is likely to adopt a firmer price policy than Gulf Sulphur Corporation whose recent advent on to a difficult world market entails the adoption of a very flexible price policy.

Ente Zolfi Italiani can look with satisfaction upon its price and sales policy as a result of which a respectable export tonnage of Italian brimstone has once more entered world markets. With the aid of the export subsidy of up to L.11,000 per metric ton (£6 8s. per ton), the general price level L.23,000-25,000 per metric tons f.o.b. (£13 7s.-£14 10s. per ton) for Buona Sicilia (min. 98% S) and Gialla Inferiore (99% S) is believed to afford

some further flexibility as lower prices appear to be in force when it is necessary to compete with U.S. or Mexican supplies in selected markets.

In Chile, the past export business based on commodity compensated prices of $18-$22 is virtually at an end as, since last year, no further licences have been officially granted on this basis. The effect of inflation on operating costs in the sulphur industry has been drastic and well informed sources indicate that at current rates of free market exchange f.o.b. prices of U.S. $40 may be necessary to reimburse producers adequately. From Columbia, modest exports to Peru are reported at about U.S. $34 per metric ton f.o.b. Many producers of recovered sulphur serving local markets have in recent weeks reduced their prices to make allowance for the reduction in sea freights which has effectively lowered the delivered cost of U.S. and Mexican seaborne supplies.

The following table attempts to indicate, broadly, the delivered cost of brimstone of varying origin at principal consumers' destinations based on tramp charters concluded on the London market at the end of March.†

Canadian by-product pyrites concentrates are seeking markets at prices ranging from $2.40 per short ton ex-mine to $3.50 to $5 f.o.b. At the present reduced east-bound freight rates they are once more highly competitive with European pyrites.

Freights

The rapid recession of sea freight in recent weeks may be attributed almost entirely to the collapse of international grain trading. The view is widely held that the exorbitant freight levels of the closing weeks of the year failed to affect significantly Frasch sulphur shipments from the Gulf of Mexico to U.K. and Europe or pyrites shipments from Spain and Portugal. Australian, Far Eastern and Indian brimstone destinations and pyrites charters from the Eastern Mediterranean had reacted most strongly, and the continued closure of the Suez Canal prolonged the adverse position.

For transatlantic freights the weakest market was early in March when coals from Hampton Roads receded to 60/- to 65/-. The slight rally towards the end of March was not reflected in sulphur charters, which as indicated, are at present transacted at about 87/6 to 90/- for the Continent and 95/- for the United Kingdom. The relative abundance of handy-sized vessels seeking cargoes in European waters has profoundly eased pyrites chartering. Recent fixtures from Huelva to the Antwerp-Hamburg range include charters at 34/- for Antwerp and 32/6 for Rotterdam. At these levels of transport cost pyrites regain some of their attractions to the Continental users, and are, of course, very favourable in Germany.

f.o.b. Country of Origin	*U.K.*	*N.W. Europe*	*France (Mediterranean)*	*India*	*Australia*
U.S.A. $27—28	... (95s.) £14$\frac{3}{8}$—14$\frac{3}{4}$	(87/6)£14 —14$\frac{3}{8}$	(90s.) £14$\frac{1}{8}$—14$\frac{1}{2}$	(190s.) £19$\frac{1}{8}$—19$\frac{3}{4}$	(140s.) £16$\frac{3}{8}$—17
Mexico $24—26.50	... (95s.) £13$\frac{3}{8}$—14$\frac{1}{4}$	(87s.) £13 —13$\frac{7}{8}$	(90s.) £13$\frac{1}{8}$—14	(190s.) £18$\frac{1}{8}$—19	(140s.) £15$\frac{3}{8}$—16$\frac{1}{2}$
Italy L.23,000 per metric ton	... (50s.) £15$\frac{7}{8}$	(42/6) £15$\frac{1}{2}$	(30s.) £14$\frac{7}{8}$	(85s.) £17$\frac{5}{8}$	
Canada $20 ex-works per short ton	(130s.) £15$\frac{1}{4}$—18$\frac{1}{2}$	(120s.) £14$\frac{3}{4}$—18	(120s.) £14$\frac{3}{4}$—18	(160s.) £16$\frac{3}{4}$—20	(160s.) £16$\frac{3}{4}$—20

Pyrites

Whereas there have been no changes in the basic price of £4 10s.-£5 per metric ton f.o.b., basis 48% S, which applies to deliveries by the principal European pyrites producers, there have been some small reductions of differential premiums, occasioned mainly by lower world copper prices. Spanish pyrites, accounting for the largest share of exports, remain price leaders, but the present price relationship may be jeopardised partly by steeply rising costs occasioned by surging inflation in Spain but more decisively by the termination of differential exchange rates* and the revaluation of the Peseta on a uniform basis, a possibility foreshadowed early in March by the new Minister of Economics.

Supplies

The apparent maintenance in the U.S.A. of the high production levels of Frasch sulphur perpetuates, for the time being, last year's trend of rising stocks. The U.S. economy in the first quarter of 1957 was seasonally active and the adjusted index of industrial activity—usually a reliable pointer to sulphur and sulphuric acid demand—stood at 149, i.e. six

* Authorised by Spanish Government 8th April. Peseta 117.60/£1.

Freight indications ( ) have been reduced to f.i.o. terms to provide a common basis for comparison.

points higher than one year ago. The resultant moderate additional demand is readily met in the first place by recovered and imported brimstone supplies and also by other forms of recovered sulphur so that the off-take of Frasch sulphur is stagnating. Frasch sulphur producers are strongly promoting sales at home and especially in export markets but it is expected that modifications to production schedules may be inevitable before long when stocks approach the 4½ million tons mark.

The realisation of production plans of the established producers in Mexico is raising output to an annual rate of 1 million tons. Pan-American Sulphur Company and Gulf Sulphur Corporation were joined at the beginning of March by Texas Gulf Sulphur Company at Santa Anita in modest but active production. In the face of strong competition Mexican producers are expanding their sales in the U.S.A. especially in the south and in overseas markets, and their ability to supply relatively clean, low cost material enables them to keep the initiative. Stock expansion continues but is not yet thought to have exceeded prudent levels.

In Italy the sulphur industry appears to be on the verge of an important change of production policy*. Fused sulphur output is receding—in 1956 it was 7% below that of the preceding year—and the supply of crude sulphur ore for domestic use in sulphuric acid manufacture is rising rapidly. In 1956 it expanded about 25% and during the current year it is expected to reach 400,000 tons ore, about one-quarter of total output. The satisfactory level of 1956, sales of 231,827 metric tons, of which 120,967 metric tons were exported, entailed recourse to stockpile supplies which receded by 60,000 tons to 276,538 metric tons at the end of the year. Prompted by Ente Zolfi Italiani, the Italian Government is reported to have laid claim to certain prerogatives with regard to immunity from sulphur imports and the imposition of customs duties under the European Common Market provisions.

Sulphur supplies in Chile are reported to be severely curtailed due to rising costs and producers' inability to export competitively without the aid of compensation payments from imported commodities.

Production at the Tixan sulphur ore deposits in Ecuador is reported to have ceased in recent months, due to the company's inability to compete in South American markets.

Recovery

The effect of the disruption of the crude oil supplies on recovered sulphur output at oil refineries in the United Kingdom and Europe was less pronounced than had been feared in 1956, but became apparent this year. In Spain, recovery of brimstone and liquid SO_2 from smelter gases is making a useful addition to pyrites based supplies and is likely to obviate the need for imports. In Scandinavia, the continuance of the high level of production by Orkla sulphur might be affected by the recession of copper prices.

Pyrites

Exports from Cyprus in 1956 reached a new peak at 992,759 tons cupreous and iron pyrites, 11% more than in 1955. This outstanding performance was achieved notwithstanding the terrorist unrest on the island, a strike at the mines of the Hellenic Mining Company and above all the adverse effect of the Suez Canal on shipping availability in the Eastern Mediterranean.

After a weak start of requisition at the turn of the year, the decline in freight rates has significantly boosted pyrites export shipments notably from Spain, Portugal and Norway.

European pyrites in general remain in good supply but there is some apprehension that demand may turn patchy if freight rates should rise again. Offers of Canadian pyrites concentrates are again on the market although Cuban supplies on account of lower copper prices may find it difficult to remain competitive. The supply of by-product concentrates from Avoca, Eire, is imminent and exhaustive flotation tests are being evaluated to determine the most suitable product range. By a recent trade agreement Czechoslovakia is to receive this year 40,000 tons Finnish pyrites concentrates. Sulphur supplies in the form of pyrites and high purity brimstone are reported to be in short supply in Central European Iron Curtain countries.

Outlook for 1957

Whereas the pressure of mounting supplies of U.S. and Mexican Frasch sulphur may be said to have been the keynote of last year's world sulphur picture, 1957 is advancing under the shadow of ever-expanding new capacity of recovered sulphur throughout the world.

* See Quarterly Bulletin 12, p. 18.

Estimates of new production tend to be out of date as soon as they are made as a rapid sequence of announcements of new projects in Canada's natural gas schemes, amongst oil refineries in the U.S.A., U.K. and Europe add to the known projects amongst which the output of high purity brimstone at Lacq which is starting next month is likely to have the most profound influence on world trade. Side-by-side with projects leading to brimstone recovery, there are significant expansions of by-product sulphuric acid production and, generally as part of integrated projects, the use of by-product pyrites. In the U.S.A. these "alternative" supplies are expanding at so rapid a rate that together with recovered and imported brimstone they are wholly taking up the market expansion with the result that domestic Frasch sulphur outlets are likely to remain limited at about 4.0 million tons per annum in spite of mounting output and approaching completion of new projects.

The rôle of pyrites as sulphur mineral is fast being superseded in Europe. In the major importing countries the attraction of pyrites rests primarily on the use of residues as an economic blast furnace feed in the form of purple ore or sinter. Whilst the rising value of the iron content may thus confer on pyrites the means of regaining a measure of resistance to competition it cannot prevent the gradual encroachment of more economic sources of sulphur supply.

The general trend in brimstone for the current year points to an increase in world trade excluding Mexican shipments to the U.S.A. of 7% to about 2.2 million tons. At the same time the volume of world brimstone stocks which at the beginning of January amounted to 4¾ million tons is likely to expand to over 5¼ million tons by the end of the year. The main feature in the emergence of new sources of recovered brimstone and Mexican Frasch sulphur is the use of the price weapon as the principal means of securing a share of the world market. Despite this, the U.S. Frasch sulphur producers may be expected to remain the dominant suppliers for some time to come and in the coming year their share of world brimstone trade should not be less than three-quarters and two-thirds of U.S. domestic supplies in all forms. They realise, however, that any modest price reduction would be matched by the majority of competitors at home and abroad and that a telling reduction, which is still within their power, would be most hurtful to themselves and to the sulphur industry as a whole. In view of the general rise in costs in the U.S.A., which is already reflected in operating expenses and in narrowing profit margins, this aspect may dictate price policy and result in an overall increase.

United States Sulphur

Frasch Sulphur

PRODUCTION of Frasch sulphur in 1956 of 6,427,229 long tons was the highest in the industry's history and the increase of 694,000 tons (12%) over the previous record year, is the largest rise in output since 1936/1937, when several new domes entered operation. Monthly production† rose from 476,313 tons in February to the peak output of 621,130 tons in July and then gradually declined throughout the remaining months without however falling below 514,772 tons in November. This generally high level of production started in mid-1955 after the heavy depletion of stocks resulting from the high level of domestic consumption. The recovery of stocks from their unduly low level has been rapid, and producers stocks, about equal to one year's domestic use, at the end of December 1956, totalled 3,936,450 long tons, compared with 3,181,198 tons one year ago.

	1956	*1955*	*Change*
	000 Tons		*%*
Texas Gulf Sulphur Company	3,376	2,952	+14½
Freeport Sulphur Company	2,393	2,078	+15
Jefferson Lake Sulphur Company	456	485	−6
Duval Sulphur & Potash Company	164	169	−3
Standard Sulphur Company	22	59	−63
Total	6,427*	5,743	+12

* Includes allowances for vat bottoms and other minor variations.

† For further details see Statistical Appendix.

About 90% of the addition to stocks is understood to be held by Freeport and Texas Gulf Sulphur Companies of which the latter is said to be responsible for well over 80%.

During 1956 Frasch sulphur was produced at 13 plants of which the small plant on Freeport Sulphur Company's Nash dome in Texas was closed in November owing to the high cost of production.

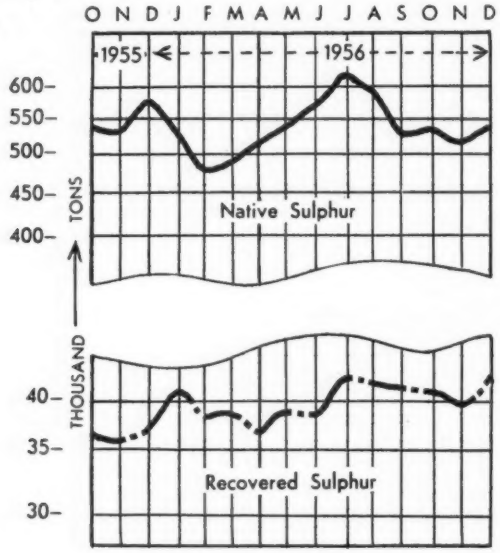


Fig. 3. Monthly Production.

Apparent sales of Frasch sulphur at 5,671,977 tons were 118,000 tons lower than the previous year's as a result of reduced deliveries to the home market although this was to some extent off-set by a modest expansion in exports. The main factors seen in relation to overall brimstone use are the increasing consumption of Mexican off-colour sulphur at acid plants in the south and on the eastern seaboard and the recovered sulphur supplies offered at competitive prices. In contrast, exports of 1,651,597 tons were at a record level, 3¼% greater than 1955. This was achieved in the face of strong competition, the most important markets being Canada, United Kingdom, France, Australia and New Zealand, which accounted for two-thirds of U.S. shipments.

Recovered Sulphur

Production of recovered sulphur attained a record total of 480,980 tons and was 79,330 tons greater than 1955. During the year this important source of supply was augmented by new plant capable of yielding 300,000 tons of sulphur annually. New projects using hydrogen sulphide, either from their own refineries or purchased from local oil refineries, which went on stream during the year were Great Northern Oil Company at Pine Bend, Minnesota; Montana Sulphur & Chemical Co. at Billings, Montana; and Aurora Gasolene at Detroit, Michigan. Expansions of existing sulphur recovery capacity at oil refineries were carried out at the Freeport Sulphur Company's recovery plant at Westville, New Jersey; Hancock Chemical Company at Long Beach, California; Sinclair Refining Company at Marcus Hook, Pa., Gulf Oil Company at Port Arthur, Texas, and the Union Oil Company of California at its Santa Maria Refinery.

In addition to these projects what is the world's largest sulphur recovery plant based on oil refinery gas was completed by the end of the year but did not commence production until the New Year. The plant, which was built by the Ralph M. Parsons Company of Los Angeles, has a capacity to produce 340 long tons per day high purity elemental sulphur and is the eighth unit to enter production at the Tidewater Oil Company's Delaware refinery which when completed in the summer will have a throughput capacity of 130,000 barrels per day.

Other important sulphur recovery plants to commence operations were those of J. L. Parker at Levelland, Texas, Signal Oil & Gas Company at Tiogo, Wyoming, and the Stanolid Oil and Gas Company at Odessa, Texas. All of these plants are based on the cleaning of sour natural gas while the projected plant of Phillips Chemical Company in Andrews County, Texas, also designed to use sour natural gas, has been deferred, and at present, the company has no further plans. Stauffer Chemical Company, who started operations of a new carbon disulphide production unit in August, at Le Moyne, Alabama, based on the reaction of natural gas and sulphur also has facilities for the recovery of sulphur in the effluent gases. The plant, which can recover up to 140 tons per day sulphur, will permit the company to manufacture CS_2 at highly competitive rates.

The favourable location of sulphur recovery plants in relation to consumers is

attributable to the high rate of increase (20½%) in apparent sales which totalled 481,801 tons in 1956. The close alignment of sales to monthly output is now an all-the-year-round feature and stock-building has for more than two years been practically non-existent. Stocks at the end of December, 1956, totalled 119,446 tons compared with the revised figure of 120,267 tons at the end of 1955.

Other Sulphurous Raw Materials

It is estimated production of sulphur in other forms totalled 1,190,000 tons compared with 1,080,000 tons in 1955. Important additions have occurred in the use of smelter gases the principal ones being used at the plant of Garfield Chemical and Manufacturing Co. at Garfield, Utah, where up to 1,000 tons per day of sulphuric acid (100% H_2SO_4) may be recovered and the new 100 tons per day by-product sulphuric acid plant of the Anaconda Company at their smelter at Anaconda.

Based on preliminary data the production of sulphurous raw materials, other than brimstone, was as under:—

	1956	*1955*
	000 Tons	
Sulphur in :—		
Low grade ore	50	40
Pyrites	440	425
Smelter gases	400	345
H_2S and sludge to sulphuric acid ...	300	270
Total	1,190	1,080

The total of sour gas used for sulphuric acid manufacture increased although there appears to have been a decline in the use of sludge acid.

Consumption

The high rate of expansion which characterised the U.S. economy in 1955 continued into the early months of 1956 but only to be depressed to a relatively low level in July by the steel strike. Although this did not radically affect the associated industries there were indications that the advance in the general level of industry in the last four months of 1956 was only about 2% higher than the corresponding period in 1955 and reflects a general equilibrium attained in the economy.

Domestic consumption of sulphur in all forms, which in addition to the customary imports of Canadian pyrites (150,000 tons sulphur in 1956) also included the substantially increased arrivals of Mexican sulphur (236,000 tons), is estimated at 6.0-6.1 million tons, an increase of 4¼% over 1955. Sulphuric acid production closely follows the general industrial trend and production in the first six months was at an annual rate of 16.5 million tons (100% H_2SO_4) while production for the year totalled 15.8 million tons (15.76 million tons in 1956), of which about 15.1 million tons was virgin acid. New installations during the year raised capacity from 18.6 million short tons to 19.45 million tons at the start of 1957. During the last six months the industry was affected by a decline in acid consumption caused by the increase of stocks of fertiliser manufacturers and their lower level of production due to uncertain pattern of demand from farmers, the lower demand for new automobiles and the decline currently facing rayon producers. Stronger acid demand was apparent for inorganic pigments, in particular titanium dioxides, detergents, oil refining, insecticides, steel pickling, aluminium sulphate, uranium mills for ore leaching, and miscellaneous chemicals. The capacity of all these sectors of industry is increasing, the uranium industry particularly rapidly.

It is estimated that about 3.6 million tons of brimstone was used for sulphuric acid manufacture. This included a large percentage of the 240,000 tons of brimstone imported from Mexico in 1956, much of which went into immediate use and which is mainly responsible for the drop of U.S. Frasch sulphur use. An important contributory factor was, of course, the significant growth of the use of alternate sources of sulphur supply in acid manufacture mainly as a result of recovery from smelter and sour gases.

Summary 1956

(a) Production of Frasch and recovered sulphur in 1956 reached a record total of 6,908,209 long tons, compared with 6,144,944 tons in the previous year. Total supplies of sulphur in all forms, including imports, rose to nearly 7½ million tons.

(b) Apparent sales of Frasch and recovered sulphur in 1956 amounted to 6,153,778 tons compared with 6,190,291 tons in 1955. The difference is occasioned by a drop in Frasch sulphur sales by 174,000 tons, an increase of 56,000 tons in exports and an increase of 82,000 tons in recovered sulphur sales.

(c) Stocks of Frasch and recovered sulphur at

the end of 1956 totalled 4,055,896 tons, an increase of 754,000 tons during the year.

(d) Sulphur imports totalled nearly 400,000 tons of which Mexican brimstone at 240,000 tons represented an increase of over 200,000 tons more than in 1955.

Outlook for 1957

The U.S. economy in 1957 is expected to develop on similar lines to last year except that the rate of expansion of industrial activity in the first half-year may be slower and that the overall growth may not be so pronounced. The chemical industry, which has in recent years assumed the rôle of moving in advance of the general industrial trend, is, however, expected to expand at a rate in excess of 5%-6%. Investment planned for the year amounts to $1,756 million on which compares with $1,468 million in 1955 and is about the same in real terms as last year.

Although sulphur is at present freely available and sulphuric acid production facilities were sufficient to meet demand there are several projects already in hand to expand the capacities of both these products to meet the rising demand. Additional demand for sulphuric acid may be anticipated for the leaching of uranium ores when six mills start operation this year. Similarly expanding capacity for titanium dioxide manufacture, greater demand at oil refineries for alkylation, a rise in the production of transparent paper and aluminium sulphate all add to growing acid usage. The outlook for fertilizers shows little prospect of a significant rise in demand for the production of superphosphates and ammonium sulphate.

The principal additions to sulphuric acid capacity, many of which are designated for high analysis compound fertilizer manufacture due to enter production this year are as follows :—

Coastal Chemical Corporation	Pascagoula, Mississippi	December 1957	Annual capacity 200,000 tons
Allied Chemical & Dye Corporation General Chemical Division	Elizabeth, New Jersey	September 1957	
Best Fertilizers Co.	Lathrop, California	March 1957	Cost $1 million
International Minerals & Chemicals Corporation	Bartow, Florida	June 1957	$4 million expansion programme
Anaconda Company	Anaconda, Montana	May 1957	Annual capacity 60,000 tons
Stauffer Chemical Co.	Vernon, California	June 1957	
Oil Incorporated	Casper, Wyoming	December 1957	Annual capacity 50,000 tons
Texas-Zinc Minerals Corporation ...	Medicine Hat, Utah	October 1957	Annual capacity 25,000 tons

It is anticipated that by the end of 1957 capacity of sulphuric acid plants will be about 20.3 million tons.

In the non-acid sector only the sulphite pulp industry is expected to expand its sulphur needs. Carbon disulphide production will be dependent upon the fortunes of the viscose rayon industry which has to meet growing competition from synthetic fibres in the textile and tyre markets.

The expansion of production facilities extends from new sulphur recovery installations governed by local economics to additional dome projects by the major established producers; this is occuring whilst existing supply facilities are more than adequate. Notable examples of new brimstone recovery facilities are the 340 tons per day installations of the Tidewater Oil Company situated in the heart of a sulphur consuming industrial district in Delaware and the 50 tons per day recovery unit forming part of the American Oil Company's refinery at Yorktown Va. It is expected that in 1957 total output will rise about 30% to 550,000 tons. Large-scale production of refined native sulphur is forecast by American Sulphur & Refining Co. at Sulphurdale, Utah, where a major solvent extraction installation is projected in co-operation with the Lummus Company, and similar developments based on a different refining process are foreseen by Wyoming Gulf Sulphur Company. In addition to these developments and the expansion of by-product acid facilities and by-product pyrites use, Frasch sulphur imports from Mexico in 1957 are expected to rise to one-half million tons. The impact on U.S. Frasch sulphur producers cannot fail to be severe.

Texas Gulf Sulphur Company in 1956 attained the highest annual output of 3.38 million tons and is now faced with the decision

to continue adding to surface stocks while export and domestic deliveries stagnate or shrink. Boling dome capacity is understood to remain unimpaired and now that Spindletop dome is operating at designed rates, it is evident that a major reduction would be necessary to align production with sales. In addition, construction is well advanced on Fannett dome, a medium-sized producer capable of turning out 150,000-200,000 tons per annum, where completion is likely this year or early next. Lake Bullicamp dome continues to be developed and work is in progress at an off-shore location. Freeport Sulphur Company also boosted output in 1956 to the record level of 2.4 million tons. The termination of operations at Nash dome, a small high-cost producer, leaves four active domes, of which the old-established Grande Ecaille and two-year-old Garden Island Bay are major units. The two lesser domes, Chacahoula and Bay St. Elaine, will probably be operated very intensively during the current year, especially the latter as its plant is later to serve Lake Pelto where development is progressing rapidly. Good progress at off-shore Block 18 may be too fast for the company's plans which are believed to provide for the prior consolidation of a large domestic and overseas order book based on output from on-shore establishments.

Jefferson Lake Sulphur Company's operation of Clemens, Long Point and Starks domes yielded a slightly lower output than the peak production of 1955. Exploitation has been intensive and this may be the portent of continuing decline as all are relatively small formations. The company's large-scale entry into U.S. and especially Canadian sulphur recovery operations, the capacity of which already exceeds her present production, is significant. Standard Sulphur Company output at Damon Mound, which in 1956 shrunk to a negligible 22,000 tons, is unlikely to operate this year as its costs are believed to be unremunerative at present prices.

It is evident that the U.S. Frasch industry in 1957 will be unable to reap the benefit of the opportunities which it has created, in the expansion of its facilities and the preparation of markets in which its world-wide influence has been unchallenged for over 20 years. Nevertheless, it must not be overlooked that at worst, U.S. Frasch producers in 1957 will still meet one-third of total world usage, two-thirds of U.S. consumption of sulphur in all forms, and 70% of world brimstone trade.

SULPHUR IN MEXICO

THE continued expansion of Mexico's sulphur industry, based primarily on the exploitation of the dome deposits on the Isthmus of Tehuantepec, has become a national asset of major importance. It is wholly fortuitous that its growth virtually coincides with the new and successful climate in Mexico's economy ensuing from the decisive policy revision in 1954 which culminated in the devaluation of the Peso. Since then, her foreign trade has boomed, her foreign currency reserves have steadily increased and rising capital imports have been supplemented by substantial re-investment of the not inconsiderably increased earnings of Mexico's industry and people. On every one of these counts sulphur has contributed to Mexico's prosperity; additional sulphur exports in 1956 represented about 4% of the increase in Mexico's exports which, compared with 1955, rose U.S. $132 million (10¼%) to U.S. $1,435 million. The aggregate value of sulphur shipments in 1956 of about U.S.$12½ million represented 0.9% of the value of the country's total exports. The inflow of capital from abroad in 1956 is reported at about U.S. $110 million. On the basis of actual installations of plant and ancilliary facilities, the investment by the U.S. parent companies of the Mexican registered sulphur operating companies is estimated to have accounted for 12%-15% of this total.

On the production side the sulphur industry expanded its output by 57% over 1955, the most spectacular achievement of the country's versatile mining industry which showed an all-round improvement of 6%. The statistical picture of the activities of the various Mexican sulphur producers, not including the modest production of sulphur

rock some of which is refined, appears to be as follows :—

	Frasch	*Recovered*	*Total*
		Tons	
Production ...	745,000	30,000	775,000
Export deliveries ...	481,568	—	481,568
Domestic deliveries ...	40,000	27,000	67,000
Stocks, 1.1.1956 ...	347,000	3,000	350,000
Stocks, 31.12.1956 ...	554,000	6,000	560,000

The principal contribution to these impressive results was made by the Pan-American Sulphur Corporation whose successful operation at Jaltipan dome has been responsible for establishing Mexican Frasch sulphur as a reliable source of supply to U.S. and overseas brimstone consumers. Typical of a young industry, the past year brought adversity, in the failure of Mexican Gulf Sulphur Company's San Cristobal dome, and success, in the realisation of the plans of the new Frasch sulphur installations at Las Salinas dome of Gulf Sulphur Corporation. At the same time the preparations, realized in the New Year, for new production by Texas Gulf Sulphur Company at Santa Anita dome, a major Frasch sulphur plant project by Texas International Sulphur at Texistipec and the possibility of the exploitations in concert with Mexican Gulf Sulphur at Nopalapa and finally tentative exchanges between Freeport Sulphur Co., and Sulphur Export Corporation regarding the latters Mexican sulphur concessions enhance the prospect of rapid expansion of brimstone production facilities. The placing in world markets of this mounting output remains the industry's main problem.

PAN-AMERICAN SULPHUR COMPANY

Facilitated by the expansion of water supply and boiler plant which from September onward added 50% to the original plant capacity and raised it to 5 million gallons daily, Frasch sulphur output at Jaltipan dome totalled 625,000 tons in 1956. Nearly 60% more than in 1955, part of the new production became available with a substantially lower carbon content having been subjected to one or two stage filtering in a new installation which had been put into operation in the late summer. Removing about one-third of the carbon content at each pass through the diatomaceous earth filters the plant is capable of producing cleaned material, with a carbon content not exceeding 0.3% and improved colour, at a daily rate of 2,000 tons. Shipments in 1956 totalled 418,328 tons of which 385,580 tons were directed to exports, the balance being delivered to the expanding domestic market, making the company the principal domestic supplier. Of the company's exports nearly 45% were directed to the U.S.A., 11% to South Africa, 12½% to the United Kingdom, and 25½% to Europe and the balance of 6% to Australia, Canada and Tunisia. In accordance with the established policy of placing into storage vats at the mine, tonnage

Pan American; general view of the expanded water supply installations.

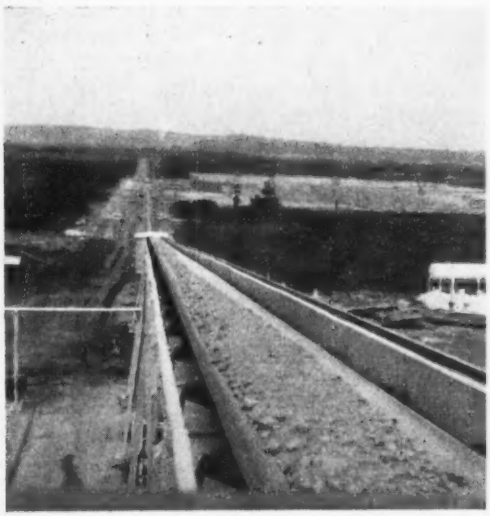
proportionate to production and sales, a further increase in stocks to about 490,000 tons was effected during the year. Of this, about one-third is reported to be filtered material.

In 1957 output is planned to reach 750,000 tons representing three-quarters of available capacity. Continued favourable water ratio, said to be less than 1,400 gallons per ton of sulphur, makes the company one of the lowest cost producers in the world and given an adequate volume of sales, promises satisfactory financial results. In this respect the company reports a good order book and President H. C. Webb has declared his confidence in the company's ability to continue the expansion of sales and deliveries commensurate with the greater output. Whereas the sulphur markets in the United Kingdom and European countries are expected to provide substantially increased outlets, it is understood that the main expansion will occur in the U.S.A., the company's principal market.

GULF SULPHUR CORPORATION

After the satisfactory start of production on 3rd May, 1956, Frasch sulphur at the company's Las Salinas dome during the remaining eight months of the year totalled 110,800 tons. Reported to be assaying on average 99.5% plus and with carbon content of 0.4% the crude material appears to show the best quality of any Mexican production so far. Nevertheless, to realise the best possible price in world markets the management decided to install a filtering plant which is designed to reduce the carbon content of the output to under 0.25%C. The plant, built at a cost of U.S.$\frac{1}{4}$ million, was completed and put into operation on 22nd February, 1957.

The company's entire sulphur output to date which in the New Year has continued at a daily rate of about 550 tons has been transported to the free port of Coatzacoalcos in liquid sulphur barges. Pending the commissioning of the company's own vessels in



Gulf Sulphur Corporation; conveyor belt from storage vats to quayside.

February 1957 barges were hired from the Mexican Gulf Sulphur Company. Similar arrangements were made in respect of loading and shipping, the company's own $1 million dock facilities being completed and coming into use in October, 1956. Special attention was paid to the siting and construction of the storage vats which, to avoid subsidence already apparent on other vats in the port area, were built on strong supports well back from the quayside.

During 1956 the company is reported to have contracted for 75,000 tons of which 52,700 were delivered to export and 2,100 tons to domestic users. The bulk of deliveries were destined for the U.S. market and included the first shipment on 25th December under a 10-year contract with Davison Chemical Co. covering 700,000 tons. The close of the year also saw the successful sale of $\$\frac{3}{4}$ million 6% convertible debentures which provides required capital for the new filtering plant, other capital equipment exploration and additional operating resources.

In a letter to stockholders on 26th February, 1957 Mr. Stuart C. Dorman, President, summed up as follows: "In our first year of operation we have given attention to establishing a sound plant, properly staffed; adding experienced operating personnel at our offices in Houston, New York, Mexico City and Minatitlan; and developing a strong sales programme which can be successfully followed for future years."

TEXAS GULF SULPHUR COMPANY

Although the company's barge-mounted Frasch sulphur plant was in position on the Coachapa River last November and water pipes, sulphur lines, and well equipment were all in place and tested, sulphur production at the Santa Anita dome was deferred and only started on 1st March, 1957. The company is reported to be aiming for an output of about 75,000 tons in 1957 which it is believed, will be well within the capacity of both plant and dome. Early production reports refer to "fairly bright" output, but this is not considered an adequate or reliable indication for the ultimate quality of output. A decision about the installation of a filtering plant, understandably, appears to be still in abeyance nor is it as yet known whether the output is to be marketed from Coatzacoalcos or from Galveston.

TEXAS INTERNATIONAL SULPHUR COMPANY

The reorganisation in 1956 of the company's control, finances and administration under the guidance of President Dale R. Major and Vice-president A. S. Makris culminated in the closing months of the year in

the announcement of an intensive exploration of the company's 123,000 acre concession area and the initiation of negotiations to exploit the company's first sulphur dome at Texistipec which is said to have proved reserves of 5 million tons sulphur. In addition to its revenue from important oil properties in east Texas the company received substantial backing from a financial group headed by the Guarantee Trust Inc. of Houston and early in January the completion of successful negotiations of an agreement was announced which provided for a 1,000 tons per day Frasch sulphur plant to be built by Fish Service de Mexico, S.A., a subsidiary of the similarly named U.S. parent engineering company. The $3\frac{1}{2}$ million plant is due for completion on 1st March, 1958, construction being facilitated by the accessibility of the Texistipec plant site by road and rail. Central Minera S.A., Texas International Sulphur Company's Mexican operating subsidiary, will own the plant but Fish Service is to maintain active management control of the operation. It is also reported that part of the plant cost is to be paid in Texas International Sulphur Company stock.

An important development concerning the exploration and exploitation, if warranted, of sulphur domes in the Nopalapa area has formed the subject of three cornered negotiations with Fish Engineering Company and Mexican Gulf Sulphur Company, to which reference is made below.

MEXICAN GULF SULPHUR COMPANY

The failure of San Cristobal dome at the close of 1955 set aside the great hopes and expectation which the company, the first active Mexican Frasch sulphur producer, had placed in the presence of abundant reserves. The existence of a stockpile of about 50,000 tons enabled it to meet most of its export and domestic contractual commitments although some assistance in the form of deliveries by Gulf Sulphur Corporation had to be sought. Export shipments in 1956 totalled 45,400 tons and the leasing of liquid sulphur barges and dock facilities at Coatzacoalcos to Gulf Sulphur Corporation secured some additional revenue. Notwithstanding exhaustive exploration no further commercially exploitable sulphur resources could be found on San Cristobal dome and negligible production continued from a few minor pockets at a rate of about 900 tons per month.

The resignation of Mr. Paul Nachtman as President but not as director of the company was followed by Mr. J. T. Claiborne Jnr. assuming the Presidency. Under his auspices the negotiations, referred to above, with Fish Engineering Co. and Texas International Sulphur Company were initiated and in a recent letter to stockholders, Mr. Claiborne seeks support for his action which he hopes will safeguard their previous investment. The contract signed between the parties provides for the joint exploration of three concessions totalling 27,000 acres in the Nopalapa area, the nearest of which is about 4 miles from the company's hot water plant at San Cristobal. These concessions are believed to include two sulphur domes and part of a third, Santa Anita, the other part of which is already being exploited by Texas Gulf Sulphur Company. The hot water supplies to Nopalapa and more distant points are to be met by the San Cristobal Frasch plant, which is being examined by Fish Engineering Co., together with other relevant engineering matters. Finally if exploitation of the Nopalapa dome became commercially feasible Texas International Sulphur Company on assuming all Mexican Gulf Sulphur's financial liabilities (including the $5 million loan from Export/Import Bank) would exchange three Mexican Gulf shares for one Texas International Sulphur Company share. Some of the company's shareholders are understood, already to have signified their assent to these proposals, but agreement may be complicated by the demands of a stockholders committee which appears to press for continued efforts to make San Cristobal dome work.

Mr. Claiborne can point to the finding of independent experts, Messrs. de Golyer and MacNaughton Inc., appointed by Export/Import Bank, whose conclusions on past exploitation and absence of workable reserves uphold the management's view. The outcome will be known after the annual general meeting on 16th April when a decision in favour could perhaps transform the ashes of Mexican Sulphur's first failure into a foundation for future success.

UNITED KINGDOM SULPHUR

CONSUMPTION of sulphur in all forms during 1956 totalled 1,110,000 tons, an increase of 49,000 tons (4½%) compared with that in 1955. This result contrasts with the general tenor of industrial production which was 3% lower than the record achieved in 1955. The chemical industry continued to show a marked expansion although this was not as great as in previous years due to adverse factors on the home market. In the export market the value of chemicals rose to a new record of £244 million.

The United Kingdom sulphur industry operated in 1956 under the stimulus of free market conditions for the first time since the imposition of Government controls in 1939 The coincident completion of large-scale anhydrite acid facilities lessened the full impact of abundant brimstone supplies and delayed the clear emergence of a new consumption pattern until the second half of the year. Apart from the important part played by sulphur in anhydrite, the greater usage of brimstone at the expense mainly of pyrites and also of spent oxide, was then apparent.

Production

Anhydrite production, the prime source of indigenous sulphur supplies, is estimated to have totalled about 1.65 million tons containing about 345,000 tons sulphur, of which about 42% was used for sulphuric acid production, the remainder for ammonium sulphate manufacture. Of the three principal mines—Billingham, Long Meg and St. Bees Head—only the last named, which supplies the acid plant of Solway Chemicals Limited at Whitehaven, is working substantially below capacity having been planned to allow for the installation of up to two additional kilns.

Production of brimstone recovered at oil refineries and from spent oxide is estimated to have totalled 53,000 tons. The restriction of the customary oil supplies from the Middle East, caused by the closure of the Suez Canal and interruption of the oil pipeline to the Mediterranean, and its partial substitution by sulphur-free oil from the Gulf, affected sulphur recovery only towards the close of the year and output did not drop appreciably. Plant capacity remained unchanged; the next expansion phase is due to start in 1958 when the second recovery unit at Esso refinery at Fawley comes on stream. Other projected recovery plants, by the Shell and British Petroleum Companies, are expected to add about 40,000 tons to existing capacity.

	1956	*1955*	*Change %*	*4th Qtr. 1956*	*4th Qtr. 1955*	*Change %*
Elemental Sulphur:						
Acid: Imported	261,600	248,600	+ 5¼	71,900	70,400	+ 2¼
Recovered, H_2S and Filter Cake	32,400	24,100	+ 34½	9,300	5,800	+ 60½
Total "Acid" Sulphur	294,000	272,700	+ 7¾	81,200	76,200	+ 6½
Regular	112,400	110,800	+ 1½	27,500	30,200	— 9
Total Elemental Sulphur	406,400	383,500	+ 6	108,700	106,400	+ 2¼
Pyrites	393,700	457,000	—14	83,200	108,700	—23½
Spent Oxide	252,200	260,900	— 3½	69,300	65,400	+ 6
Anhydrite	697,700	382,200	+ 82½	179,700	113,200	+ 59
Zinc Concentrates	187,900	200,400	— 6¼	51,800	44,900	+ 15½

Indigenous supplies expanded, chiefly on account of greater demand for anhydrite, and are estimated to have accounted for 52% of total consumption. The changed consumption pattern permitted a significant (23%) reduction in pyrites imports, while withdrawals of brimstone from stocks and the use of imported filter cake, facilitated a modest (1½%) reduction in brimstone imports. The import bill for about 547,000 tons sulphur in all forms of £8.37 million was 8½% less than in 1955.

Extensive works on the improvement of by-product plants at town gas works and coke ovens, notably those of the National Coal Board, have included mechanised handling equipment for spent oxide in the form of tower box purifiers. The most important project completed in 1956 was the integrated National

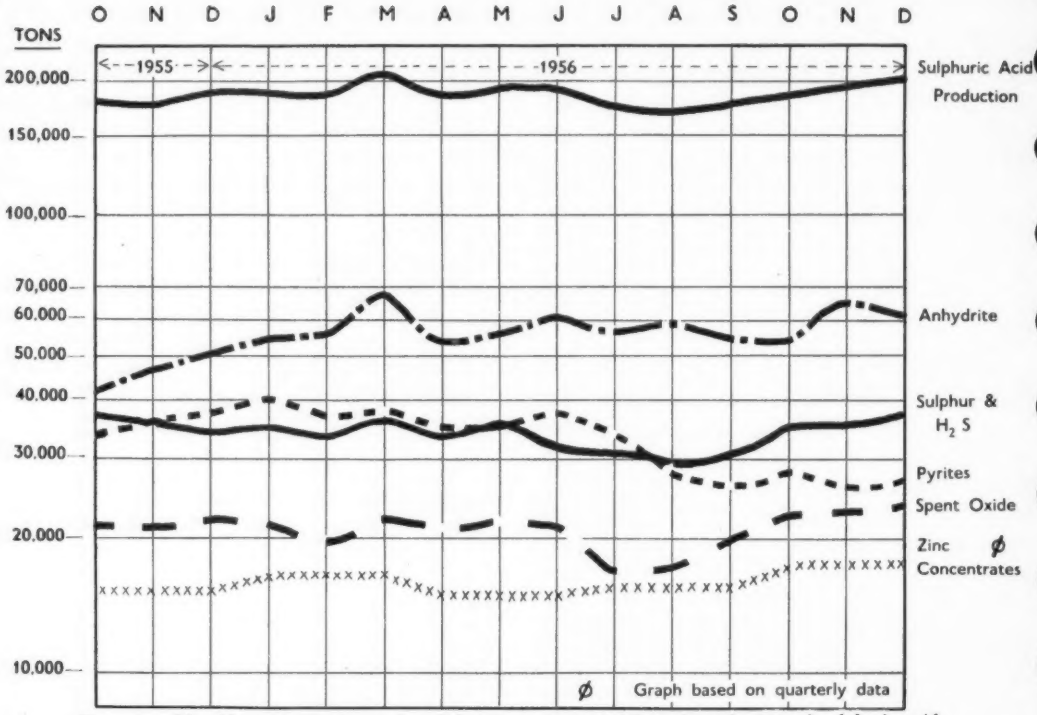


Fig. 4. Monthly consumption of sulphurous raw materials and production of sulphuric acid.

Coal Board coking plant at Wingerworth which includes a 50 tons per day sulphuric acid plant. The gap between spent oxide production and domestic use and exports closed during the year, and stocks are once more rising. Recovery of sulphur from the smelter gases of the zinc plants at Avonmouth and Swansea of the National Smelting Corporation declined about 6% compared with 1955. A plant expansion programme providing for an increase of about 17% in zinc production has been drawn up and it is believed that it will provide a corresponding expansion of sulphuric acid capacity.

It is estimated that the production of indigenous sulphurous raw materials was as follows :—

	1956 thousand tons	*1955 tons*
Sulphur in :		
Anhydrite	345	281
Recovered at oil refineries and from spent oxide ...	53	46
Spent oxide	130	130
Pyrites (coal)	1	1
By-product acid at smelters	57	61
By-product acid from H_2S	7	6
Total	593	525

Consumption

The expansion of 4½% in sulphur use in 1956 is due primarily to increased requirements for sulphuric acid manufacture, based on the growing needs of selected industries, notably chemicals, steel and agriculture. Prominent amongst individual users are the manufacturers of titanium dioxide, detergents and phosphatic and nitrogenous fertilizers. Comparative data is as follows :—

	1956 thousand tons sulphur	*1955*	*Change %*
Anhydrite for ammonium sulphate manufacture	193	191	+1
Sulphuric acid	805	760	+6
Non-acid uses	112	110	+2
	1,110	1,061	+4½

" Regular " Sulphur Consumption

Consumption of regular sulphur rose by 2% to 112,400 tons during 1956. Determined by the rate of output of the rayon and rubber industries which in turn were affected by the fortunes of the car industry, consumption of non-acid sulphur during the first six months was at a record level and correspondingly

declined during the second half-year. In this period output of man-made fibres was 3½% lower than in the second half of 1955, but 1956 output, which totalled 483 million lbs., was 2% greater. This tonnage includes fully synthetic fibres output of which is estimated to have risen by 22 million lbs.

Consumption of sulphur for sulphur dioxide, sulphites, wood pulp and ultramarine dyes has remained substantially unchanged. Exports of ground and refined sulphur declined from 2,200 tons in 1955 to 1,300 tons in 1956. It may be anticipated that sulphur requirements for carbon disulphide will increase in 1957 to meet the needs of Messrs. Courtaulds Limited's new factory at Grimsby. Added demand is also expected from I.C.I.'s new synthetic rubber plant at Wilton, due to enter production shortly.

Sulphuric Acid*

Production of sulphuric acid during 1956 totalled 2,251,000 tons (100% H_2SO_4), an increase of 134,000 tons (6¼%) compared with the previous record total of 1955. The largest rise in production was registered in the first six months of 1956 when output was 100,000 tons greater than in the corresponding period 1955.

Effective capacity of sulphuric plants available for acid manufacture in 1956 at 2.79 million tons (100% H_2SO_4) was over 200,000 tons greater than the previous year.

This increase in capacity is mainly attributable to the new brimstone acid plant of Scottish Agricultural Industries Ltd., at Leith, the pyrites based plant of British Titan Products Ltd., at Grimsby, the National Coal Board plant at Wingerworth using spent oxide and the increase of productive capacity at plants which have converted their pyrite roasters to sulphur burners, notably West Norfolk Farmers, at Kings Lynn, and Scottish Agricultural Industries at Aberdeen, and Scottish Oils Ltd.

Overall 80.8% of effective capacity was employed. The planned expansion of U.K. acid capacity by the addition of new plants, almost exclusively based on brimstone use, is expected to add about 100,000 tons new capacity each in 1957 and 1958. Prominent amongst these projects are Fisons Limited's plant at Immingham for triple superphosphates, British Titan Products Ltd., at Grimsby for titanium dioxide manufacture, and Laporte Acids Limited, also for titanium dioxide.

Acid production resulted from the use of sulphurous raw materials in the following proportions :—

	1956 %	*1956* % *4th Qtr.*	*1956* % *3rd Qtr.*	*1955* %	*1955* % *4th Qtr.*
Sulphur					
Imported brimstone	32½	34½	34¼	32½	35
Recovered, H_2S and Filter cake	4	4½	4½	3	3
Sulphur in :					
Pyrites	23½	19	22¼	28½	25¾
Spent Oxide	15	16	14½	16½	15½
Anhydrite	18¼	18¼	19¼	11½	14
Zinc concentrate	7	7½	7¼	7¼	6¾
Total Sulphur 000 tons	805	207	184	763	201

Acid Consumption

Consumption of sulphuric acid in 1956 at 2,248,500 tons (100% H_2SO_4) showed an increase (112,000 tons) of 5¼% over 1955. Three-quarters of the increased usage occurred in the first half-year and the slowing down of the rate of expansion must be attributed to the effects of industrial stoppages and fuel rationing.

Acid usage by the main consumer groups was as follows:—

	1956	%	*1955*	%
Superphosphates	520	23.1	491	23.0
Ammonium Sulphate	300	13.3	285	13.3
Chemicals	296	13.2	270	12.6
Titanium Dioxide ...	274	12.2	232	10.9
Rayon and Transparent Paper	268	11.9	261	12.3
Metallurgy ...	127	5.6	125	5.9
Soap, Glycerine and Detergents ...	77	3.4	58	2.7
Oil Refineries ...	63	2.8	61	2.9
Dyes	77	3.4	81	3.4
Plastics	40	1.8	35	1.7
Miscellaneous ...	206	9.3	238	11.3
Total. (Thousand tons)	2,248	100	2,137	100

Major changes in acid consumption compared with the previous year were as follows :—

	Change *Tons*	%
Titanium Dioxide	+41,900	+18
Superphosphates	+29,100	+6
Soap, Glycerine and Detergents ...	+18,800	+32
Sulphate of Ammonia ...	+15,200	+5½
Explosives	−8,500	−29½

*We are indebted to the National Sulphuric Acid Association for information placed at our disposal.

Other important changes, though quantitively smaller were recorded for agricultural purposes (+31%) Vegetable oils (−20%), Plastics (+13%), Sulphates of copper, nickel, etc. (+31%) and sulphate of magnesium (−42½%).

Trade and Stocks*

Imports of brimstone in 1956 amounted to 353,657 tons, valued at £15 3s. per ton representing a total value of £5.36 million which was fractionally lower than in 1955, whereas the tonnage declined 1½%. U.S. suppliers lost some ground to Mexican French sulphur and recovered brimstone imports from Trinidad declined mainly due to lack of suitable shipping facilities. Pyrites imports totalled 385,440 tons valued £7 10s. per ton. Quantity and value declined by 22½% compared with 1955. The import of 12,000 tons filter cake from the U.S.A. valued at £10 6s. per ton lost some of the inherent economic advantage due to the incidence of relatively high freight cost.

At the end of the year stocks of regular and acid sulphur, and including filter cake, totalled 84,600 tons, which represents about 11 weeks' usage at current rates. Stocks of pyrites of 212,200 tons and stocks of spent oxide of 130,200 represented 33 weeks and 25 weeks' usage respectively.

Outlook for 1957

Whereas in the opening months of 1957 the country's economy continued to be characterised by last year's stagnation of industrial production, which if anything was aggravated by industrial stoppages, it is widely held that the prevailing climate in international trade supplemented by budgetary policy, will result in a significant acceleration of output in most sectors of industry during the second half of the year. The effect on United Kingdom sulphur consumption is not clear cut. There is little doubt that the needs of fertilizer, titanium dioxide, plastics and some chemicals manufacture will continue to expand at rates not dissimilar from last year's when these sectors showed contrasting strength to the rest of the economy. The viscose rayon industry, an important user of brimstone and sulphuric acid is an uncertain factor as it is facing heavy competition, not only in world markets but also from other fibres, although Courtaulds, Ltd., are opening a new staple fibre factory which will add nearly 40% to existing capacity.

It is anticipated that overall sulphur usage will expand about 5% to about 1,170,000 tons, of which about 50% will be indigenous sulphur.

Imports are, however, expected to decline as nearly 90,000 tons of acid and regular sulphur, representing old Government stocks wholly in the form of U.S. Frasch sulphur, are to be taken into ordinary consumption. Sulphuric acid output may be expected to expand to 2.4 million tons, mainly on account of greater use of available brimstone acid capacity and the installation of new plants. Improved spent oxide handling and H_2S utilisation may be expected to expand the uses of sulphur so extracted from coal carbonisation gases. Output of anhydrite acid and by-product acid at zinc smelters may be expected to continue near capacity of over 400,000 tons and 160,000 tons per annum respectively. Pyrites usage faces a further decline, possibly by as much as one-quarter, to near 300,000 tons.

Thus the pattern of sulphur use which clearly emerged in the second half of last year may be expected to establish itself more firmly on the basis of peak use of indigenous anhydrite, recovered brimstone and H_2S, and the consumption of imported low cost Frasch sulphur.

NATURAL GAS IN CANADA

By the autumn of this year natural gas piped from Alberta will be reaching important industrial centres in Canada and the U.S.A. through the pipe lines of the Westcoast Transmission and Trans-Canada Pipe Lines Companies. Response to these projects has been such that the two companies are already planning expansion and securing their future supplies. The importance of natural gas to Canada's economy is revealed by the recently presented Gordon Report which points to the changing pattern of energy use:—

Type of energy†	*1926* %	*1953* %	*1980* %
Coal	69	39	16
Petroleum	10	42	45
Natural Gas	2	4	25
Wood	16	7	1
Water Power	3	8	11
Nuclear Power	—	—	2

*For further details see Statistical Appendix.

† Each course as a percentage of total energy consumed in terms of tons of coal equivalent.

At present the focus of development is in Alberta where exploitation of the oil and natural gas fields is governed by the Petroleum and Natural Gas Conservation Board of Alberta which ensures that this liquid and gaseous wealth is used to the best advantage, in the light of present and future needs. Sharing in the extensive Williston basin are the oil and gas fields in Saskatchewan which are as yet comparatively undeveloped. A recent discovery in Quebec offers prospects of a natural gas production in Eastern Canada.

The advent of large scale natural gas supplies is stimulating industrial growth along the path of the pipelines, whereas in the gas field region where cheap power is commonplace the benefit on industrial development is derived mainly from the essential cleansing and by-product operations amongst which sulphur recovery is prominent. The majority of crude gas supplies contain varying percentages of H_2S of which for every one million cu. ft. extracted, about 40 short tons of brimstone can be recovered. Two such gas cleaning and sulphur recovery plants at Taylor and Pincher Creek

Fig. 5.

which are designed to process gas for transmission through British Columbia to the U.S.A. and eastward across Canada to Montreal respectively have completed the initial development.

Apart from the expansion of these two plants it has recently been announced that a further two gas cleaning and sulphur recovery installations are to be built to meet the call for increased gas supplies projected for future years.

Natural Gas in the West

The Westcoast Transmission Co. Ltd., was formed in 1949 to build a 650 mile pipline from the Peace River fields to Huntingdon on the British Columbia/U.S.A. border, primarily for the export of gas into the U.S.A. but also to supply British Columbia. The company which is owned by Pacific Petroleum (22½%) Sunray Mid-Continent (25%) Pacific Northwest

Amine reboilers and still reflux condensers at the Taylor gas cleaning plant.

Pipelines Company (25%) bases its initial requirements of gas on Pacific Petroleum's fields in the Peace River area on the borders of British Columbia and Alberta.

As a result of growing demand Westcoast Transmission Company in January, 1957, announced a major expansion programme. The installations at Taylor and the 30″ pipeline now under construction from the Peace River gas fields through British Columbia are to be increased by 55% to 660 million cu. ft. daily. This will permit the supply of 300 million cu. ft. to Pacific Northwest Pipeline Company for transmission to the U.S.A. and the full contractual quantities to the two provincial gas distributing companies, British Columbia Power Corporation (132 million cu. ft.) and Inland Natural Gas (59 million cu. ft.). For additional delivery to users in Oregon, Washington and Idaho States, Pacific Northwest Pipelines further purchased 325 million cu. ft. from Westcoast Transmission Company who, to augment its sources of supply, entered into an agreement to purchase sour gas from Phillips Petroleum Company at Savanna Creek in south west Alberta. Here, treatment facilities of up to 125 million cu. ft. gas are foreseen in

conjunction with a sulphur recovery plant and ancillary facilities, which include a 174 mile pipeline to the U.S.A. border. Expenditure is projected at $45 million, whereas the expansion of the Peace River project is to cost $55 million.

The sulphur recovery operations in conjunction with the gas cleansing plant at Taylor, are being effected by Jefferson Lake Sulphur Company and the two companies are also believed to be co-operating at Savanna Creek. By the end of this year, sulphur output will start at the Taylor plant. Initially output will be 300 tons per day and will double when the gas flow reaches maximum designed level. Then, probably early 1959, Savanna Creek is expected to contribute 500 tons per day bringing the company's sulphur capacity to nearly 400,000 tons per annum high purity brimstone.

Natural Gas to the East

Despite the delays caused by bad weather, construction work on Trans-Canada's Pipeline up to the end of the 1956 construction season was progressing favourably. Plans have now been announced for the raising of public funds

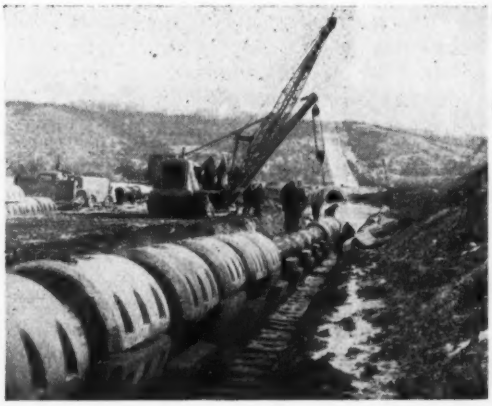
Trans-Canada's pipeline being laid at Swift Current Creek in Western Saskatchewan.

and also for construction work by the Crown Corporation to begin on the Northern Ontario leg. The company has been licenced by the Petroleum and Natural Gas Conservation Board of Alberta to export 620 million cu. ft. of gas per day or alternatively at an annual rate of 183,000 million cu. ft. to 1981. The company has to date concluded 47 contracts with natural gas producers in 14 fields in Alberta.

Natural gas will be collected by the Alberta Gas Trunk Line Co., Ltd., for delivery to Trans-Canada's Western pipeline terminus at Burstall. The proved gas reserves in the gathering area are estimated to be 7.3×10^{12} cu. ft. of which Trans-Canada has currently contracted to 4.5×10^{12} cu. ft. The remainder may be available to Trans-Canada and competing companies after the provincial needs have been satisfied.

Trans-Canada Pipelines placed on the market earlier this year issues for $230 million to finance the cost of the pipeline. This was mainly provided by Insurance Companies and other institutional investors.

It is anticipated that gas supply line will be completed to Winnipeg by September of this year and to Port Arthur and Fort William



Trans-Canada; a 260 foot section double coated and wrapped and protected with rock shields is being weighted to cross the Assinboine River at Miniota, Manitoba.

at the head of the Lakes by November. Subject to authority from the Federal Power Commission, the company intends to import gas into the Montreal area simultaneously, pending completion of the North Ontario leg not later than November, 1958. The Crown Corporation which has a capital of $120 million was founded by the Federal and Ontario Governments. The cost of the 675 mile section in North Ontario which forms the middle part of the Trans-Canada's pipeline is estimated at $118 million of which one third (or a maximum of $35 million) will be paid by the Ontario Government. Mr. D. A. Golden, President of the Crown Corporation, said that they had agreed to complete the section between the Manitoba-Ontario border and Port Arthur by

November 1st, 1957, and the rest of its portion to Kapuskasing, Ontario by November 1st, 1958. At present the Tennessee Gas Transmission Company is delivering gas to the Toronto area but has agreed to withdraw its supplies as soon as the Canadian pipeline is completed. In exchange, Canadian natural gas would be piped to the mid-western U.S.A. if a permit is obtained from the U.S. Federal Power Commission. The Precedent Agreement calls for the sale of 200,000 million cu. ft. of gas per year for 25 years by Trans-Canada to be delivered to Emerson, Manitoba, on the International boundary. The Tennessee Gas Transmission Co., have assigned the purchase of the gas at Emerson to the Mid-western Transmission Co., a subsidiary company who plans the establishment of a large gas distribution system in the United States.

According to Trans-Canada's President, Mr. N. E. Tanner, marketing forecasts for natural gas are as under:—

Period	*Maximum Daily Consumption (mill. cu. ft.)*	*To be Supplied From*
Nov. 1957 - Nov. 1958	56.2	Bindloss and Provost fields
Nov. 1958 - Nov. 1959	290.4	Sibbald, Oyen, Cessford, Princess Patricia, Atlee - Buffalo, Pincher Creek fields
Nov. 1959 - Nov. 1960	376	

Delay in the start of requisitions from Pincher Creek at a contracted rate of up to 100 million cu. ft. per day in the first year, may be due to the relatively small scale of operation until the end of 1958. In the meantime British American Oil Co., is progressing with development work in the gas field, one of the largest in Canada, and the gas cleaning plant at Lethbridge, designed to recover daily 225 tons of sulphur and 2,200 barrels of concentrates of gas daily which after treatment is returned to underground storage. Eventual plans of British American Oil Co. provide for sulphur recovery at an annual rate of 307,000 tons at Pincher Creek and 100,00 tons at Nevis.

The most recent development concerns the exploitation of the gas field of the Socony Mobil Oil Co., located in the Calgary area and favourably sited in relation to the gas collection system of the Alberta Trunk Line. Drillings recently carried out by the company have indicated substantial reserves of sour natural gas and an agreement has recently been concluded with Jefferson Lake Sulphur Co., of New Orleans to develop the property. The site covers an area of 80,000 acres and it is understood that Jefferson Lake Sulphur is currently planing the drilling of wells, in addition to the erection of gas cleaning and sulphur recovery plant, which will have a daily capacity of 350 tons high purity brimstone.

Trans-Canada; the 34 inch pipeline being coated and wrapped.

Summary

Now that the financing of Canada's pipelines has been resolved with a capital investment of $1,300 million, the provision of cheap power across the Continent has been turned into reality. Inevitably this also stimulates the developments of a heavy chemical industry in the gas field area where indigenous supplies of practically every basic chemical raw material are offered under favourable operating conditions. This applies especially to fertilizer plants and chemo-metallurgy in which the use of sulphur plays an important part.

The potential arising of sulphur is vast and indications preclude the possibility of local requirements of the pulp and paper industry of British Columbia, and the metallurgical industries in Alberta and Saskatchewan of taking more than a small proportion of the total recovered. There will, therefore, remain an impressive export surplus which is expected to exceed one-half million tons annually by 1960 and may be as much as one million tons. The disposal of this output to users in the home and export markets is dependent on an equitable transportation cost.

SULPHURIC ACID PRODUCTION BY THE PETERSEN SYSTEM

General

A NEW contact sulphuric acid plant employing the Petersen system entered operations towards the end of 1955 at the Krefeld Works of Guano-Werke A.G. The plant which has a daily capacity of 60 tons (100% H_2SO_4). has a conversion rate of 98% of available sulphur from the SO_2 gases and will work efficiently and economically at an output varying between 26 and 80 tons per day (100% H_2SO_4). The SO_2 gases are generated by the roasting of flotation pyrites in a FluoSolids roaster of the type developed by the Badische Anilin-& Soda-Fabrik A.G.

The Petersen system developed by Hugo Petersen of Wiesbaden, finds application in both tower and contact plants. A notable feature of Petersen towers is the conversion to 60° Bé sulphuric acid of gases of fluctuating concentration and volume, even as low as 1% SO_2. This is achieved by double regeneration of the gases and automatic conversion of the SO_2, as well as NO—Oxidation at capacities up to 150 kgs. 60° Bé H_2SO_4 per cubic metre (10lbs. cu/ft). The Petersen contact process converts the sulphurous gases by means of a vanadium catalyst in Horden kettles, the correct temperature being maintained by the use of either three or four heat exchangers. Capable of using pyrites, zinc blende, copper and lead ores, elemental sulphur, H_2S or any other gases containing SO_2, Petersen plants are designed to convert 98% of available sulphur content in the case of pyrites and 98.5% in the case of brimstone and to produce concentrated sulphuric acid or oleum.

Drying and Cleaning

The roaster gases are first cooled, then cleaned in a gas purification plant and to ensure that they are optically clear before entering the drying tower, gases are passed through wet cottrells. Developed by the company to a special design, they have a rectifier built into the top of the filters and each cottrell has its own voltage regulator permitting its operation at peak efficiency and voltage, and avoiding high voltage outside the apparatus. In the case of the new installation of Guano Werke A.G., at Krefeld gas purifiication plant and wet cottrells to the design of and built by Lurgi were specified and incorporated. The clean and purified gas enters a drying tower where it meets strong sulphuric acid, good contact between acid and the gas stream being promoted by a "Pallring," which—developed and patented by Badische Anilin-& Soda-Fabrik—helps to ensure that moisture content of the gases is reduced to under 50 mg. per cubic metre (2grs. 100 cu/ft).

Circulating acid is strengthened continuously by acid drawn from the absorber, while drying acid diluted by the addition of the moisture from the gas stream is run through a cast iron cooler for heat removal and thence to a tank for pumping back into the absorbing tower.

Conversion

The gases are transferred to the converter by means of a blower; a droplet catcher is installed between the drying tower and the blower to remove any acid mist, thereby also preventing corrosion of the blower. Finally before entering the converter, in order to prevent the formation of ferrous sulphate and its deleterious effect on the catalyst on account of sintering, the gases are once more filtered—through glass wool—and are then optically clear and as clean and dry as practically possible. The converter unit consists of the converter itself, four heat exchanges and the pre-heater; the latter, used only when starting the plant, is designed as a pipe heat exchanger with special heat resisting material. Initially dry air from the pre-heater raises the temperature of the converter to 400°C; then SO_2 gases are admitted, preheated and converted to SO_3, and heat developed by the reaction further raises the temperature of the converter. Temperature is maintained at the correct level by four heat exchangers which are so connected as to ensure the optimum temperature in the different catalyst layers of the converter. To attain a high velocity of reaction, temperature is rapidly allowed to rise at the start of conversion and the first stage is run at a high temperature; the two following stages of conversion are at much lower temperatures in order to obtain a high conversion ratio of SO_2 to SO_3. Gas temperatures are controlled throughout and

the best operating conditions are stated to be as follows:—

	1st Stage	*2nd Stage*	*3rd Stage*
		Degrees centigrade	
Inlet	410	450	430
Centre	520	470	435
Exit	560	490	435

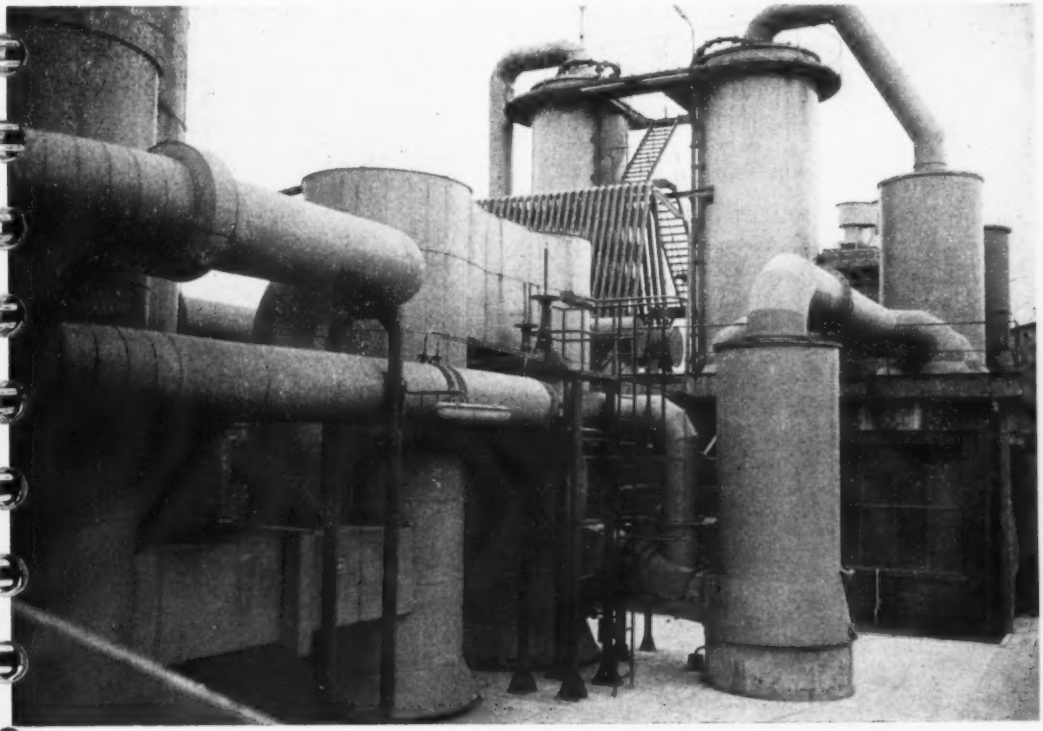
The converter using a vanadium catalyst gives the following conversion ratio of available sulphur content.

1st Stage	72 - 78%
2nd Stage	92 - 94%
3rd Stage	98 - 98.5%

All parts of the plant which are running under higher temperatures are heat insulated in order to avoid losses by radiation and convection.

Absorption

The contact gases leaving the converter are cooled in the heat exchanger to approximately 180°C and further cooled by air in the gas cooler to avoid a sudden drop in temperature in the absorption tower which would result in the formation of acid mist. Similar to the drying tower, the absorption tower is constructed of mild steel, bricklined and filled with special filling material. Sulphuric acid of 98.3-98.8% strength is circulated and heated by the absorption reaction. The acid on leaving the absorption tower is cooled in a cast iron cooler before it is fed again to the absorber. The concentration of the recirculated acid of the absorber is automatically controlled by a constant supply of weaker acid from the drying tower, and there is a water supply to the absorber circulation.



The Petersen contact sulphuric acid plant of Guano-Werke A.G. at Krefeld.

Conclusion

The development of the Petersen system has been much influenced by the predominant use by Germany's acid industry of pyrites and of sulphur in other forms, qualitatively less attractive to the acid maker than pure brimstone. Petersen contact acid plants are capable of treating SO_2 gases resulting from this wide range of sulphurous raw materials as well as from brimstone, efficiently and economically. The main emphasis of design

and construction appears to centre on high conversion efficiency and longevity of plant. Conversion rates are claimed to be normally up to 98.4% and since SO_3 absorption is said to be practically complete, the acidity of exit gases is so low that no plume can normally be seen on the tail gas chimney. These features and the reduction of plant corrosion are attributed to the high degree of purity and absence of moisture from the roaster gases and special attention is therefore paid to the purification sections of the plant. Messrs. Hugo Petersen of Wiesbaden established over 50 years ago, have to date completed the construction of over one hundred sulphuric acid plants in all parts of the world.

Explosion Prevention by the Graviner System

General

THE annual reports of the Chief Inspector of Factories and other authorities show that explosions occur in many branches of industry and in many types of plant. A large percentage of these explosions is in grinding plants where finely divided inflammable materials readily form explosive concentrations.

Until recently, precautions have been mainly confined to the use of blast walls and conventional bursting discs. This account is concerned with the Graviner Industrial Explosion Protection System which is designed to bring an explosion under control before the pressure reaches a dangerous value, and in the majority of cases the final pressure does not, in fact, exceed 3 p.s.i. The equipment has been developed from the aircraft fuel tank explosion suppression system, the basic principle of which is the detection of an explosion within a few milliseconds of its initiation.

An explosion does not occur instantaneously, and the time taken to reach a given pressure follows approximately a cube law. The larger the vessel, the longer the time taken to reach a given pressure, while the final pressure depends on the explosive mixture, its concentration and on the initial pressure, e.g., a petrol explosion will generate about 110 p.s.i.g. when initiated at one atmosphere, sulphur about 40 p.s.i.g. and coal dust about 45 p.s.i.g. The tendency of a material to explode is largely determined by the minimum spark energy required for ignition and by the ignition temperature. It is interesting to note that in the case of sulphur both of these are lower than for coal dust. It is also noteworthy that, since sulphur is such a good insulator, it can accumulate a static electrical discharge of high potential which further increases the possibility of ignition. In general it is claimed that any explosive mixture which when ignited in a confined space reaches maximum pressure in not less than 40 milliseconds can be brought under control by the Graviner system.

It employs five basic methods namely Suppression, Venting, Advance Inerting, Isolation and Automatic Plant Shut-down which are employed singly or in combination.

Suppression

As an explosion requires a definite time to reach maximum pressure it is possible by rapidly introducing a suitable suppressant to arrest the growth of the explosion flame before

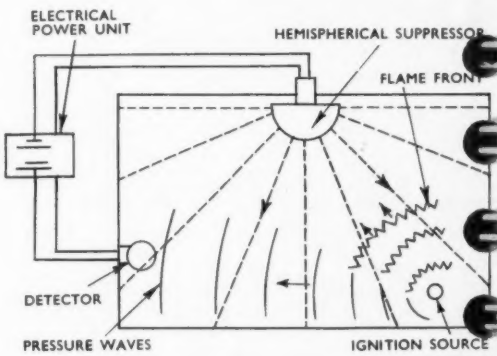


Fig. 6.

a dangerous increase of pressure occurs. This technique is known as Suppression, and a simple suppression system is shown in Fig. 6. The detector is of the pneumatic type

which operates whenever a pre-determined rate of rise or a static pressure setting is exceeded. The two settings ensure the earliest possible detection of either a fast or slow explosion at a pressure usually not greater than [illegible] p.s.i. above the normal working pressure. Pressure waves travel at approximately 1,000ft. per second and flame speeds usually vary from 1 to 15ft. per second, an explosion will be detected before the flame front has progressed more than a few inches. On detection, suppressant is ejected from the hemispherical suppressor at about 200ft. per second and extinguishes the flame before it can increase sufficiently to produce a dangerous pressure.

Hemispherical Suppressor.

The Hemispherical Suppressor consists of a hemisphere filled usually with CB (Chloro-bromo-methane), with an electrically fired detonator located at its centre. When the detonator is fired the suppressor opens rapidly and the suppressant is ejected at high velocity as an expanding hemisphere of fine droplets.

A 3″ High Rate Discharge Bottle is used where Hemispherical Suppressors might affect the efficient operation of the plant, as in the case of cyclones or ducting. The bottle contains CB pressurised with dry nitrogen to 250 p.s.i.g. which is ejected when the frangible plug at the bottom of the bottle is disrupted by the firing of a detonator located inside the plug.

Operating current for the firing of the detonators in conjunction with the explosion detector is supplied by an Electrical Power Unit. This can also be used automatically to shut down the plant when the protection system operates; in most cases this is a desirable feature. The apparatus is provided with a number of safeguards, including protection against power failure and damage to external circuits.

Venting

Venting is extensively used to permit explosion pressure to exhaust itself to atmosphere. Plant safeguarded by this method should also be inerted to avoid a secondary fire.

There are many types of vent which can be used and most of the conventional bursting discs or relief doors rely on the explosion pressure to burst or operate them. As this is not always considered to be acceptable, Graviner have developed a detonator-operated "Armourplate" glass Bursting Disc which is ruptured by the same method as that described for a suppression system. In addition to having the advantage that a small relief area can be used, these discs are not affected by temperature or fatigued by pressure fluctuations and therefore have an indefinite life.

Advance Inerting

One of the great dangers of explosions is that they will propagate through ducting from vessel to vessel, as for example where a common dust extraction system is provided for a number of vessels. By the rapid injection of suppressant into a section of the plant away from the seat of an explosion this can be prevented. This is known as Advance Inerting and is effected by means of ¾″ High Rate Discharge Bottles.

Isolation

An alternative method of preventing the spread of flame is to isolate one section of a plant from another, which can be done by means of a Detonator-operated High Speed Isolation Valve. An 8″ valve of this kind will close in about 80 milliseconds from the moment of detection.

Application

Many types of plants are already being protected by these methods. Figure 7 illustrates a system which has been successfully applied to sulphur grinding in this country. The grinder

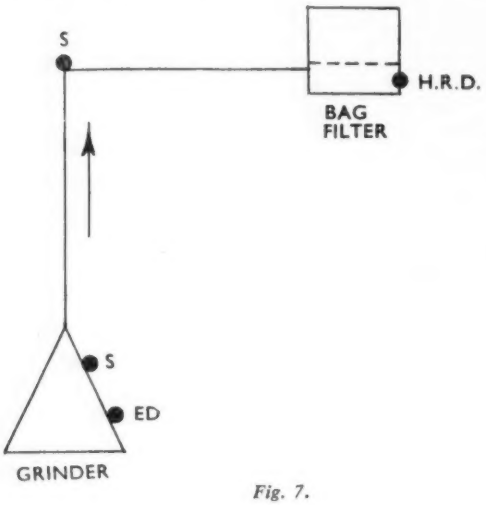


Fig. 7.

is provided with an explosion detector(ED) and a hemispherical suppressor(S) and the bag filter with a high rate discharge bot (H.R.D.),

The object of the hemispherical suppressor located in the ducting is to minimise the effe of any flame which may escape from th grinder and cause a rise of pressure in the ducting and bag filter. The grinder in thi case is operated by compressed air and known as a "Microniser".

The Graviner System has now been installed in plants concerned with the proces ing of Wood Flour, Porridge Oats, Pulverised Fuel, Pyrites, Sulphur, Plastics, Cellulose Acetate, Icing Sugar, and protection has be provided in Spray Driers, Bucket Elevato Systems, Pneumatic Conveyors and Altitude Test Tanks. More than 20 cases of effecti operation are known to have occurred, si of which were on sulphur handling plants.

We are indebted to Sir Vernon Brown of t Graviner Manufacturing Co. Ltd. for the account and diagrams kindly placed at our disposal.

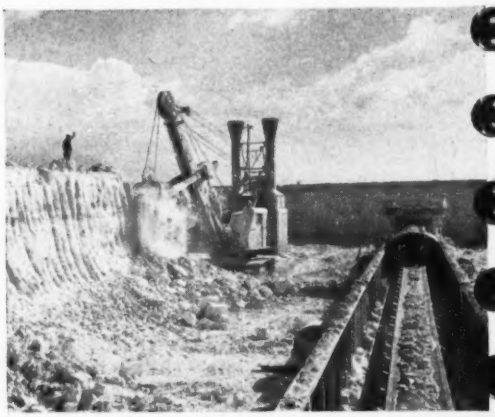
Company Reports

Freeport Sulphur Company

Mr. Langbourne M. Williams presented the company's 44th Annual Report in his new capacity as Chairman and President. He reports that sulphur production and sales were the highest in the company's history and that net earnings in 1956 established a new record for the fifth consecutive year.

Sulphur

The company's record production was attributable to the full operation of the Grande Ecaille dome and expansion of activities at Garden Island Bay. Other domes operated during the year were Bay St. Elaine, Chacahoula and Nash, although the last named, a small high cost property, ceased operations in November. Sales of sulphur totalled just over $68 million an increase of 9¼% compared with 1955 the previous record year, and attributable to the vigorous sales policy pursued in a highly competitive market. Turning to new developments Mr. Williams referred to the company's Lake Pelto sulphur deposit on which engineering work and



Conveyor belt fed by electric shovel carries ore one-half mile to dockside.

preparation of the mining site has started and he also outlined the agreement made recentl with Humble Oil and Refinering Co. for the development of the off-shore salt dome known

as Grand Isle-Block 18.* The company is at present waiting for the approval by the Department of the Interior for the assignment of three leases after which similar action will be sought from the State Mineral Board of Louisiana. Upon approval the company will proceed with the design phase of the Grand Isle deposit for which two years will be required followed by two years for construction.

Other Company Activities

Oil: Following the successful launching of the Freeport Oil Company last year production from the company's operating division at 1,975,000 barrels of oil increased 2% over the previous year's production. This rise in output is mainly attributable to the development of the Lake Washington field in Louisiana. Although the company made a loss of nearly $1 million last year the higher level of activity projected for 1957 should result in a profit.

Nickel and Cobalt: Pilot plant work on the process to extract nickel and cobalt from ore bodies at Moa Bay, Cuba was successfuly concluded and the United States has requested the company to submit details of a project to produce 50 million lbs. of nickel annually instead of 30 million lbs. as planned originally.

Potash: The first shipment of potash was made from National Potash Company plant at Carlsbad, New Mexico which is jointly owned by the Freeport Sulphur and the Pittsburgh Consolidated Coal Companies. The plant has an annual production of 400,000 tons of high grade muriate of potash and it is anticipated that much of the output will be a coarse grade currently in good demand among fertilizer manufacturers.

Finance

Dividend payments in 1956 rose for the first time in the company's history to $3.00 per share, compared with $2.62½ in 1955. Similarly, earnings of $5.00 per share and gross sales totalling $68.1 million were also the highest on record. Actual operating profits however rose by only $0.6 million to $15.3 million and this was supplemented by dividends from the Nicaro Nickel Company; after making allowance for Federal and State income taxes, net income advanced to $13,377,585, an increase of just under $1 million compared with the preceding year.

The company's total assets at the end of 1956 showed an increase of $5.6 million to $87.5 million; these included the value of sulphur in store, which rose 9¾% to $10.2 million, investments in Moa Bay project, the Nicaro Nickel Co., and National Potash Co., which totalled $3.1 million ($1.3 in 1955) Fixed assets in the form of land, leaseholds, plant and equipment rose from $64.1 million to $69.4 million while depreciation and amortisation advanced $5.9 million, 10% more than in 1955 thereby reducing the book value to $40.5 million.

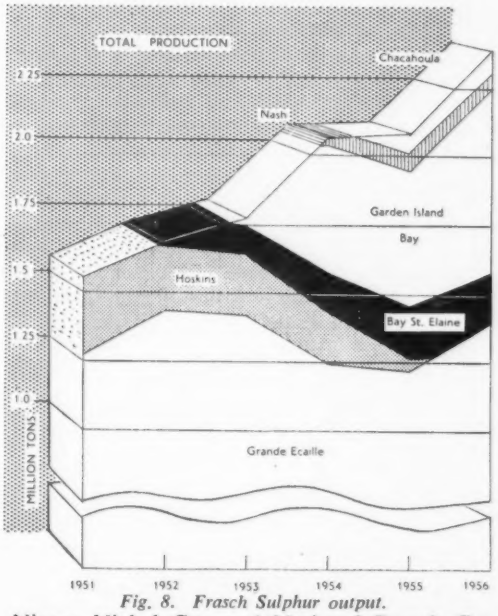


Fig. 8. Frasch Sulphur output.

Conclusion

Concluding his report Mr. Langbourne M. Williams said "While the outlook for the sulphur industry is one of increased competition, the consumption of sulphur should continue its upward trend; and our increasing productive facilities, coupled with extensive reserves of sulphur and constant improvement in customer service, put us in a strong position to maintain and enlarge our share of rising world markets. Our other mineral activities also serve expanding markets and should substantially broaden the base of our operations in the future."

* See Quarterly Bulletin 14, p. 17.

Duval Sulphur and Potash Company

In reviewing the results of the Duval Sulphur & Potash Company for the year 1956, *Mr. Geo. F. Zoffman* in the Annual Report deals with the company's developments of potash resources, the level of sulphur operations and the recent announcement that Duval Sulphur & Potash will operate a copper ore concentration plant.

Potash

The company's main source of revenue, potash operations at Carlsbad, New Mexico were maintained at approximately the same level as last year. Exploration in Eddy County, New Mexico and in the company's claim area in Saskatchewan, Canada has substantially increased reserves of potash.

Sulphur

Sulphur production at Orchard Dome, Fort Bend County, the company's only unit, was stated to be 4% less than in 1955, when it totalled 170,900 tons. Sales of sulphur, the President added, were about 25% less than in 1955 and the sale price of sulphur for export declined $3 per long ton during the early part of the year, both resulting primarily from increased sulphur production in Mexico.

The company's prospecting and exploration programme has not so far produced any results, but it will be continued.

Copper

The evaluation of the company's properties in Pima County, Arizona has established the existence of a commercial deposit of copper ore. At present the company is preparing to construct facilities for the production of copper concentrates and molybdenum as a by-product. Located in the Twin Buttes area the deposit is understood to consist of three closely related ore bodies under about 100 feet of overburden. Reserves are estimated at 80 million tons of ore and making an allowance for the waste material between the three ore bodies copper content averages 0.8-1.0%.

Finance

Primarily as a result of the decreased sales of sulphur in 1956 the company's total sales (excluding freight, allowances, etc.) at $12.2 million was $1.2 million less than the previous year. Nett operating revenue was reduced by just over $0.7 million to $3.7 million and, after making provisions for Federal and State Income Taxes, net income for 1956 was $2,506,906 compared with $3,062,827 for the previous year. The company's non-productive exploratory expense account was at $443,811, almost double that of the previous year.

Summary

The company's entry into the non-ferrous metal field further diversifies its marketing and financial interests and will result in the company's sulphur revenue accounting for a progressively smaller proportion of its total income. There is as yet no indication that the company plans to reduce sulphur output at Orchard Dome—despite the reduction of sales—below the present level of economic production at about 160,000 tons per annum.

Current Events

Sulphur Production and Consumption

UNITED KINGDOM

Brimstone Acid Plant

Messrs. Laporte Acids Limited have ordered a 170 tons per day (100% H_2SO_4) sulphuric acid plant to be built by Simon-Carves Limited, of Cheadle Heath. The new plant will augment the Company's existing production facilities which are situated at Stallingborough, Castleford, Leeds and Luton, and meet the rising needs for titanium dioxide.

AUSTRALIA

Plant Modernisation

D.H.A. (Chemicals) Pty. Ltd. are modernising their plant at Rozelle, a suburb of Sydney. A modern Simon Carves contact acid unit with an annual capacity of 7,000 tons (100% H_2SO_4) operating on brimstone is replacing the existing brimstone based chamber installation. At the same time the

company's sulphuric acid plant based on spent oxide is undergoing modification and it is envisaged that on completion of the expansion programme a greater proportion of the total sulphuric acid will be produced from the spent oxide facilities. The company does not manufacture fertilizers and the increased acid supplies will be consumed by the great variety of local industries.

CANADA

Sulphur Recovery at Nickel Smelter

Under an agreement reached between the *International Nickel Co., of Canada Ltd.*, and the *Texas Gulf Sulphur Co.*, a pilot plant is to be operated at Copper Cliff, Ontario to investigate processes for the recovery of elemental sulphur from sulphur dioxide rich gases derived from the adjacent Sudbury nickel smelter.

Mr. R. D. Parker, Vice-President of Inco and General Manager of its Canadian operations, stated that the pilot plant will be built near the site of their new iron ore recovery plant of which the first unit was placed in operation over a year ago. This development has been prompted by the large quantities of SO_2 exhausted to the atmosphere by this process and it is understood that the investigations into methods of sulphur recovery may extend over several years. An important consideration in this agreement has been the imminent availability of natural gas by way of Trans-Canada Pipe Lines as its use as a suitable reducing agent holds much promise. Media such as propane gas and heavy fuel oils will also be tested.

If the process economics prove satisfactory and Texas Gulf Sulphur Co. give approval to the construction of a large sulphur recovery plant this will be the only location in the world where a single source of sulphur, in this case sulphur dioxide contained in waste gases, may be recovered in the form of sulphuric acid, liquid sulphur dioxide and brimstone.

New Ore Concentration Plant

Consolidated Sudbury Basin Mines Limited is now well advanced in the first stage of their construction programme in the development of their large base metals property 12 miles south of Sudbury. The 1,000 tons per day flotation plant due to enter operation in June 1957 will produce copper-lead concentrates and zinc concentrates which will be sent to custom smelters, while the pyrite concentrate production which is initially estimated at 150 tons per day will be delivered for sulphuric acid manufacture. The company's plans call for erection of a mill capable of treating 3,000 tons of ore per day to be in operation by the end of 1958.

Nickel Smelter Project

The first custom copper-nickel smelter in Quebec is now under construction for the *Eastern Mining & Smelting Corporation Ltd.*, at Chicoutimi where the economic treatment of concentrates from a large geographical area stretching from the Manitoba border to the eastern seaboard is planned. The plant site, located on the Saguenay river 70 miles up stream from its junction with the St. Lawrence, is well served by road, rail and water transport facilities.

Arthur G. McKee & Company's Canadian subsidiary were awarded the general engineering and construction contract for the plant and the smelter which is based on the flash smelting process developed by Outukumpu Oy of Finland. The exact details of the utilisation of the sulphur dioxide gas from the flash smelter, which is estimated at 12%, have not yet been completed as the company has yet to examine tenders for a liquid SO_2 plant with a capacity of 180 tons per day and a sulphuric acid plant with a capacity of 400 tons per day (100% H_2SO_4).

The smelter was originally designed to treat over 200 tons of nickel-copper concentrates and 200 tons of copper concentrates daily and according to Mr. Andrew Robertson, the company's Vice-president and Managing Director, it is now intended to add a copper refinery at a cost of $7 million as an integral part of the plant. An initial $4.5 million bond issue will be launched in April of this year and a $20 million bond and $10 million convertible debenture issues are scheduled for later this summer. The company is already reported to have obtained additional financing through the J. Bradley Streit-J. A. Hackett interests who are represented on the Board together with representatives of the important Mogul Mining Corporation. Arrangements have already been made to treat concentrates from Eastern Metals Corporation Ltd., and Quebec Nickel Corporation Ltd.,

when these properties come into production. The company is expected to be able to offer attractive rates for treating concentrates from existing and future producers in the Chibougamau Camp area, the Eastern Townships mining area, south of Quebec, the Sudbury District and as far west as the Gordon Lake area, near Kenora, Ontario.

U.S.A.

Texas Gulf Sulphur Board Changes

Early in March, the company announced a number of important changes in the management of the company. Chairman of the Board, Mr. Walter H. Aldridge, the doyen of the Frasch Sulphur industry, will continue in office in an honorary capacity. The burden of duties will be carried by former President, Mr. Fred M. Nelson who, on relinquishing this appointment, has been elected Chairman of the Board. Former Vice-President and General Manager at Newgulf, Mr. Claude C. Stephens has been elected President.

Sulphuric Acid for Uranium

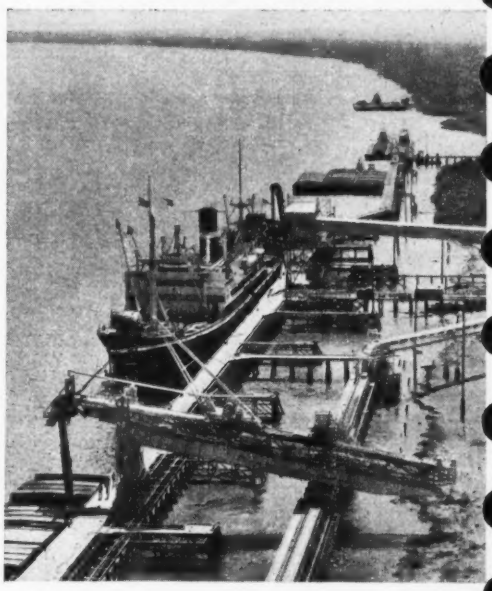
Lucky Mc Uranium Corporation of Salt Lake City, Utah have recently signed a contract with the Atomic Energy Commission for the construction and operation of a uranium processing mill. To be located in the Gas Hills area of Freemont County, Wyoming and about 50 miles south east of Riverton the mill will treat the company's own ores as well as those from independent producers in the area.

Sulphuric acid supplies for the leaching process will be obtained from *Oil Incorporated* who is constructing a new contact sulphuric acid plant at Casper, Wyoming about 70 miles distant from the uranium mill. The plant, which is also intended to supply acid to other local users, will have a capacity of 150 tons per day and will be designed to burn a combination of crude sulphur, hydrogen sulphide gas, spent alkylation acid and other refinery produced acid sludges. It is anticipated that supplies will be available by the time the uranium mill is in operation about January 1958.

Texas-Zinc Minerals Corporation, which was formed last year by the Texas Company and New Jersey Zinc Co., is building a uranium mill at Mexican Hat, Utah, with a capacity to treat 775 tons of ore per day. The plant will include a 70 tons per day sulphuric acid unit which will use elemental sulphur.

New Loading Facilities

Freeport Sulphur Company has placed in operation new dock facilities at Port Sulphur, La., designed to reduce substantially the average loading time for ships and barges. The new loader which was designed by Hewitt-Robins in collaboration with Freeport engineers was installed on an extension to the company's existing loading facilities. Built at a cost of over $1 million the loader can travel a distance of 400 feet on two sets of double rails and moves from one ship's hold



Sulphur loading installations at Port Sulphur. Liquid loading point at far end of dock.

to another in less than five minutes compared with thirty or more if the ship had to be moved. The discharge chute in addition to having a vertical clearance of 54 feet can also project from the pier up to 45 feet and is capable of distributing sulphur 20 feet in any direction. The whole system, including the ¾ mile long conveyor belt, is remotely controlled. It represents the second part of a planned expenditure of $5 million to improve distribution facilities. The first stage of their programme on new dock facilities was the installation last year of molten sulphur loading facilities which have since been enlarged to meet the growing demand from consumers for this new method of delivering sulphur.

New Fertilizer Plant

Designed to meet the growing specialised fertilizer requirements of the company's stockholders in the South, the Mississippi Chemical Corporation, one of the largest Farmers Co-operatives in the U.S.A., has recently formed a subsidiary company under the name of the *Coastal Chemical Corporation*. It will manufacture a wide range of complete high analysis granular type fertilizers mostly in the form of ammonium phosphates in addition to the production of substantial quantities of single and triple superphosphate. Capacity will be based on a 600 tons per day sulphuric acid plant (100% H_2SO_4) which, built to the design of the Titlestad Corporation of New York, will be one of the largest sulphur burning acid plants in the world. The Fluor Corporation is to supply the wet process phosphoric acid plant with a capacity of 75 tons per day P_2O_5 and also a 350 ton per day granulation plant capable of producing various grades of ammonium phosphate. The potash supplies will be obtained from New Mexico, phosphate rock from the Florida area, sulphur from the Gulf Coast and anhydrous ammonia from the Corporation's parent facilities at Yazoo City, Mississippi.

The plant will be located in a 1,200 acre site east of Pascagoula, Mississippi in the Bayou Casotte area and water transport facilities will be provided. It is envisaged that the Corporation's sulphuric acid plant and ammonium fertilizer plant will be in operation by December of this year and that this will be the first step in the development of the site as a major chemical production centre.

FRANCE

Sulphur Recovery from Natural Gas

Construction work on the installations at Lacq has proceeded on schedule and the plant is expected to enter operation in April at its initial design rate of one million cubic metres of gas per day. In the gas cleaning plant liquid petroleum fractions and H_2S and CO_2 will be recovered at high pressure and pure methane representing about 70% of initial volume is to be fed to the gas distribution network. The extracted H_2S (17.56%) is concentrated and sulphur is recovered by conventional means. It is anticipated that by the end of 1957, 50,000 tons of sulphur will have been recovered and that in 1958, the first full year of operation, some 70,000 tons high purity brimstone will be produced.

Development plans for the disposal of the cleaned natural gas and recovered sulphur from the wells of Société National Pétroles d'Aquitaine are now being formulated. The company is making arrangements for the gas to be distributed to areas south of a line Nantes-Lyons by the end of 1958 and to Paris by 1960. It is envisaged that each year from 1958 to 1963 the level of gas disposal will necessitate the start of operations of a new gas cleaning unit capable of treating some 3 million cu. metres of gas per day and yielding about 210,000 tons sulphur, thus bringing sulphur recovery capacity to 1.2 million tons by the end of 1963.

During 1957 and 1958 no export of sulphur is envisaged as the entire output is already reported to be under contract to domestic users although it is thought likely that there may be an arising of between 10,000-15,000 tons sulphur available for other than home market before the end of 1958. Once domestic needs for brimstone have been fully met it would appear that in 1959 up to 75,000 tons and in 1960 one-quarter million tons would be available for export, the export surplus being expected to rise to one-half million tons in 1961 and to 800,000 tons by 1963.

JAPAN

By-product Sulphuric Acid at Flash Smelter

By application of the Outukumpu Oy process at their copper smelting plant at Hitachi, the *Nippon Mining Co.*, is to increase further its capacity for the manufacture of by-product sulphuric acid. The process, similar to that employed at the Ashio smelter of Furukawa Mining Co., is based on the fine grinding of the copper concentrate, which is blown into the top of the furnace with pre-heated air, thus causing the combustion of the ore and resulting in the smelting of the copper, the generation of heat through oxidation, and the formation of sulphur dioxide rich gases.

After the successful completion of experiments at their Saganoseki smelter using the company's own ores it was decided to apply the process at their largest smelter at Hitachi where production up to now amounted to about 19,000 tons copper and 70,000 tons sulphuric acid (100% H_2SO_4) annually. It is anticipated that when the new plant starts

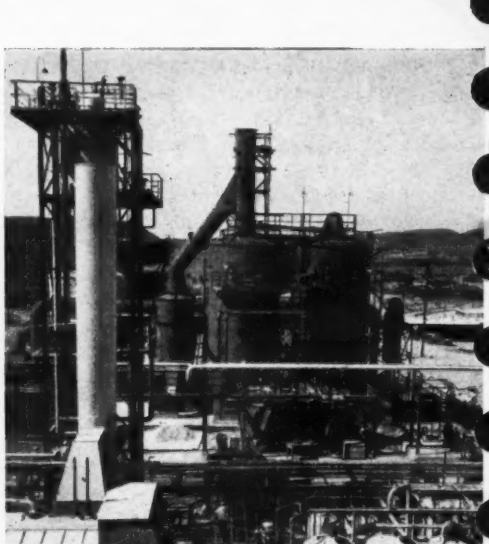
operation in the Autumn of this year the annual capacity will be raised to 24,000 tons copper and 120,000 tons sulphuric acid.

PUERTO RICO

Establishment of Basic Chemical Industry

The rapidly expanding economy of Puerto Rico has recently been strengthened by the addition of capacity to produce the basic heavy chemicals of ammonia and sulphuric acid. *Gonzalez Chemical Industries Inc.*, responsible for the project at Guanica, started operating their sulphuric acid plant towards the end of last year while production of anhydrous ammonia and ammonium sulphate is imminent. Design capacity for anhydrous ammonia is 42,000 tons per annum the bulk of which will be used in the ammonium sulphate plant which has a capacity of 400 tons per day.

The sulphuric acid plant was engineered by the Lummus Company of New York and built by the Leonard Construction Company of Chicago employing the contact process licenced by the Monsanto Chemical Co. The plant has a capacity of 350 tons 98% sulphuric acid per day and uses elemental sulphur. After meeting the company's own sulphuric acid requirements for fertilizer production it is anticipated that there will be a surplus available for local sale. Established users in the country are the rum distilleries, battery services and producers of galvanised wire; there is a growing demand from the general chemical industry and also from oil refineries where acid is used for alkylation in the production of high grade petroleums. Acid usage in the treatment of bagasse may also provide a growing outlet.



Sulphuric acid plant at Guanica prior to completion.

Puerto Rico has within the past five years attracted an increasing number of prominent U.S. chemical firms and the country is now undergoing a radical change in its economic structure. This rapid growth of industries and the attraction of established companies is attributable to the local tax exemption as well as complete freedom from U.S. federal taxes.

Industries Associated and Dependent on Sulphur

Desulphurisation at Coking Plant

The Durham Division of the National Coal Board completed in November of last year the £2 million extension to their Monkton coking plant which is now capable of carbonizing daily 1,300 tons of coal and producing about 10 million cu.ft. of gas compared with 600 tons of coal and 4 million cu.ft. gas previously. As the coke is used primarily for metallurgical purposes, the coals are chosen for their lower sulphur content. It is estimated that, at the Monkton works, H_2S content of the gas before purification is about 350 grains per 100 cu.ft. compared with over 500 grains in coal gas produced from average Durham coals.

The plant incorporates facilities for purifying the total arising of gas which is then sent to Northern Gas Board for distribution. Before the gas cleaning plant was installed the gas was cleaned by the Northern Gas Board at its own works and mixed with the Board's own producer gas prior to distribution. The purification unit consists of a set of five working towers installed by Messrs. Newton Chambers and Co. Ltd., of Thorncliffe. The trays containing the ferric oxide—a Danish bog ore—are mechanically filled and dis-

charged. It is estimated that the annual arising of sulphur will be 650 tons in the form of spent ferric oxide containing not less than 48% and probably an average 50% sulphur (on the wet basis) with a moisture content of up to 10%: the spent oxide will be sold for sulphuric acid manufacture.

AUSTRALIA

Fluidized Roasting of Copper Concentrates

The Commonwealth Scientific and Industrial Research Organisation has recently been conducting experiments into the fluidized bed technique for the roasting of copper concentrates on behalf of and in conjunction with four copper producers, Mt. Morgan Ltd., Mt. Lyell Mining and Railway Ltd., Mt. Isa Mines Ltd. and Peko Mines (N.L.) Ltd.

The experimental programme was based on 3ft. 6in. diameter pilot plant roaster in which the concentrates were subjected to a series of controlled tests in order to ascertain conditions under which a calcine with very favourable leaching properties could be obtained. The principal aims were a high rate of copper extraction by electro-deposition from the leaching of the calcine, low iron extraction, and recovery of precious metals by cyanidation. After initial difficulties of feeding the copper concentrates into the roaster in the form of a slurry and evolving an air distributor to prevent the defluidisation of the bed by agglomeration, the experiments were successful and a small 12in. diameter roaster has been constructed to enable a more detailed study to be made of some aspects of the chemistry of the roasting process.

The exhaust gases have an SO_2 content ranging between 5% and 8% and although, due to the relatively low roasting temperature (about 700°C), the SO_3 concentration is appreciably higher than in usual acid plant practice, there appears to be no technical reasons why this gas should not be used either for acid manufacture or elemental sulphur production. There is, however, little prospect of this even if the companies were to apply this process for copper production, as more than sufficient sulphuric acid could be generated in the electrolysis of the copper bearing solutions and recycled to the leaching stage. The comparative geographical isolation of the smelters appears to preclude for the time being sales of sulphuric acid to other users, notably fertilizer manufacturers but the full potentialities of this aspect and the economics of metallurgy and sulphur recovery still await comprehensive assessment.

INDIA

Heavy Chemicals Expansion

Under the second five-year plan provision has been made by the Government to expand considerably India's production capacity of heavy chemicals and fertilizers. By 1961 it is intended to produce 470,000 tons of sulphuric acid, 720,000 tons of superphosphate and 1.6 million tons of ammonium sulphate; actual production of these commodities in 1955 was 164,840 tons, 71,160 tons and 393,000 tons respectively.

At present there are 37 sulphuric acid plants in operation with a total capacity of 245,000 tons (100% H_2SO_4) while the 14 licences which have been granted for new plants and expansions will result in doubling existing capacity. In this respect the Development Council for Heavy Chemicals favours the installation of sulphuric acid plants with a capacity of at least 50 tons tons per day with a view to reducing the present multiplicity of small plants and to promote the production of cheaper acid. In its endeavour to reduce the country's dependence on brimstone imports, the Government has initiated an examination of means to produce sulphur from indigenous raw materials such as pyrites, gypsum and sodium sulphate.

The most up-to-date major project is the plant complex of Fertilizers and Chemicals (Travancore) Ltd. which is centred around the 160 tons per day sulphuric acid plant being built by Chemiebau Dr. A. Zieren and which will include manufacturing facilities for nitrogenous fertilizers and compound low and high analysis mixtures*.

At the Government owned nitrogenous fertilizer plant at Sindri an important expansion programme, in which Montecatini have rendered valuable technical assistance, is nearing completion. Based on the use of 10 million cubic feet per day coke oven gas, synthetic ammonia capacity is being boosted by 60%; this will allow the manufacture of 70 tons per day urea, and 400 tons ammonium nitrate-sulphate. Sindri's sulphur requirements will continue to be met in the form of gypsum.

*See Quarterly Bulletin No. 11, Page 28.

Other major projects destined to play a leading part in meeting India's envisaged ammonia needs are the steel plants at Rourkela and Bhakra Nangal and the lignite project at Neivelli.

TRINIDAD

Acid at Oil Refinery

A new sludge acid decomposition plant and a contact sulphuric acid plant are at present being built by the *Chemical Construction (Great Britain) Ltd.*, for the *Trinidad Oil Company* formerly known as Trinidad Leaseholds Ltd. The existing installation at the company's oil refinery in Trinidad is a sludge decomposition plant which had been built about twenty years ago by Chemical Construction Corporation, New York, and this is based on the hot coke method for decomposing the heavy sludges. The addition of new processes at the refinery in Trinidad will result in the production of larger quantities of discarded alkylation sludge containing approximately 85% sulphuric acid. This sludge requires different equipment for its decomposition and, at the same time, additional sulphuric acid is required.

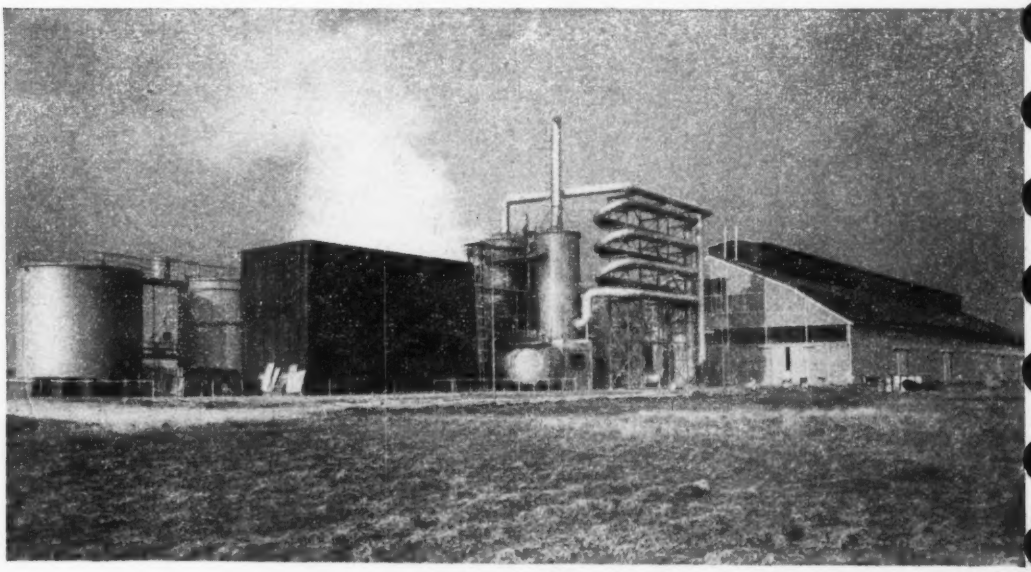
The original contract for the plants was awarded to Cyanamid Products Ltd., engineering division which has now been taken over by Chemical Construction (Great Britain) Ltd., and it is anticipated that the plants will go on stream in July of this year.

SOUTH AFRICA

New Uranium Producer

The *Buffelsfontein Gold Mining Company* is at present engaged on the construction of a £3½ million plant at Klerksdorp for the production of uranium oxide. Based on the processing of gold residues slimes the plant will have a capacity to treat 100,000 tons per month of slimes while by-product pyrites will be recovered for use in the sulphuric acid plant. The pyritic concentrate is estimated to contain 40% sulphur and will be roasted in a 24 feet diameter Dorr Reactor. The roaster gas will then be fed into a standard Chemico sulphuric acid plant which has a daily designed capacity of 100 tons (100% H_2SO_4). The sulphuric acid plant at present under construction is expected to commence operations in September 1957.

The acceptance of the Buffelsfontein Gold Mining Company as a producer of uranium now brings the total in South Africa to 31 while the sulphuric acid plant will be the 8th to supply the necessary acid for the leaching process.



New brimstone acid plant at Vlaardingen and storage facilities.

HOLLAND

Brimstone Acid for Fertilizers

The first brimstone based sulphuric acid installation in Holland has been operating since 1st October 1956 at the Vlaardingen works of *Eerste Nederlandsche Cooperatieve Kunstmestfabriek*. Prior to its erection the company derived its acid supplies from a pyrites based lead chamber plant and by purchasing substantial quantities of acid from Belgium.

Built by Simon-Carves Ltd., of Cheadle Heath to standard Monsanto design the new plant has an annual capacity of 50,000 tons 60° Bé acid and is adequate to enable the company almost to dispense with brought-in supplies of sulphuric acid. Ready conversion to pyrites roasting and the special design of the convertor and absorber are notable plant features.

In addition to the established production of single superphosphate and dependent fertilizer mixtures the company has now also embarked on production of triple superphosphates and high analysis compound fertilizers. To this end the company has also built at Vlaardingen a new factory—complete with a store capable of housing three-quarters million bags—for the production of mono-ammonium phosphate.

FINLAND

Expansion of Pulp Production Capacity

Important new plant projects are reported to be nearing completion which will raise production capacity of wood pulp mills to 2 million tons per annum. Compared with the annual output of only 1.4 million tons in 1950, Finnish pulp production in 1955 attained a record level of 1,826,000 tons of which 61% was sulphite pulp and 39% sulphate pulp. In consequence sulphur requirements of the pulp industry rose to about 125,000 tons of which about 50,000 tons was met by the use of imported brimstone originating primarily from Norway and Chile. On completion of the present expansion programme it is expected that the sulphur needs of the industry will exceed 140,000 tons of which 55% will be met by the use of about 175,000 tons indigenous pyrites concentrates while the balance representing over 60,000 tons brimstone will be sought from Norway and other overseas brimstone producers.

ISRAEL

Establishment of Rayon Industry

The vigorous industrial expansion policy now being pursued in Israel and which is largely based on the recently established heavy chemical industry in particular, is to be further diversified by the addition of a rayon industry. Although the plans are still only in the preliminary stages it is estimated that the plant will be built at a cost of $20 million for the manufacture of rayon yarn and tow.

Consideration has been given to securing sulphuric acid requirements from the plant of Fertilizers & Chemicals Ltd., at Haifa although the company may yet decide to incorporate an integrated sulphuric acid plant in their final plans.

Rogosin Industries Ltd., of New York, who are responsible for financing and organizing this project is backed by a group of U.S. financiers headed by Mr. Israel Rogosin. Mr. Rogosin is President of the Board of Beaunit Mills Inc. one of the important rayon concerns in the U.S.A.

U.S.S.R.

Sulphuric Acid/Fertilizer Production

Details of some developments in the chemical industry during 1956 were recently issued by the Central Soviet Economics Administration. Sulphuric acid output is stated to have risen by 14% during the year to 4,320,000 tons (100% H_2SO_4) while fertilizer manufacture expanded 13% to 10.9 million tons.

Statistical Appendix

United States

		PRODUCTION		STOCKS		EXPORTS	IMPORTS
		Frasch	*Recovered*	*Frasch*	*Recovered*		
1953		5,155,342	337,099	3,022,486	107,344	1,241,536	
1954		5,515,543	357,400	3,228,020	109,066	1,647,011	1,104
1955		5,743,344	401,650	3,181,198	120,267	1,595,419	38,317
1956	January	531,330	40,900	3,216,150	121,066	114,610	12,150
	February	476,313	37,100	3,194,019	121,438	137,701	2,639
	March	485,963	38,100	3,204,568	118,913	94,425	24,796
	April	504,289	36,200	3,240,373	118,760	117,072	20,119
	May	543,217	38,500	3,276,638	113,377	131,049	10,025
	June	565,002	38,200	3,330,433	111,945	157,940	12,437
	July	621,130	43,400	3,493,942	115,246	136,048	15,036
	August	597,699	42,500	3,636,730	115,047	188,240	15,347
	September	524,370	42,000	3,680,784	117,759	138,784	28,440
	October	529,056	40,750	3,705,626	118,937	192,332	23,814
	November	514,772	39,580	3,852,028	119,157	95,003	19,254
	December	534,088	43,750	3,936,450	119,446	193,624	
1956	Total	6,427,229	480,980	3,936,450	119,446	1,651,597	

Official Bureau of Mines Data (long tons of 2,240lbs.)

Italy

FUSED SULPHUR EXPORTS 1956

	Metric tons		*Metric tons*
Austria	3,272	Sweden	12,130
Czechoslovakia	3,602	Hungary	83
France	49,695	Algeria	2,31
Greece	1,250	Tunisia	14,490
Norway	1,800	Egypt	1,042
Poland	500	Israel	19,77
Portugal	3,250	Russia	7,01
Total	120,967		

United Kingdom

SULPHURIC ACID CONSUMPTION

(Thousand Tons 100% H_2SO_4)

	1955	*1956*		*1955*	*1956*
Accumulators	10.9	10.4	Oils (Vegetable)	11.2	8.
Agricultural Purposes	5.0	7.3	Paper, etc.	7.4	6.
Bichromate and Chromic Acid ...	15.6	16.1	Phosphates (Industrial)	0.6	0.5
Bromine	12.2	12.2	Plastics	35.0	39.7
Clays	11.5	10.9	Rayon and Transparent Paper ...	260.6	268.2
Copper Pickling	3.1	3.0	Sewage	11.0	10.
Dealers	13.8	12.8	Soap, Glycerine and Detergents	58.2	76.9
Drugs and Fine Chemicals ...	18.7	16.7	Sugar Refining	0.6	0.8
Dyestuffs and Intermediates ...	81.5	76.6	Sulphate of Ammonia	284.6	299.8
Explosives	28.9	20.3	Sulphates of Copper, Nickel, etc	20.4	26.
Export	3.8	4.4	Sulphate of Magnesium	2.1	1.
Glue	0.4	0.5	Superphosphate	491.0	520.0
Hydrochloric Acid	61.6	61.2	Tar and Benzole	23.2	24.9
Hydrofluoric Acid	11.4	12.8	Textiles	19.2	19.0
Iron Pickling	117.6	120.0	Titanium Oxide	231.8	273.
Leather	5.0	4.9	Unclassified	197.2	199.4
Lithophone	16.8	16.0			
Metal	4.3	3.6			
Oil Refining	60.6	62.6	Total	2,136.8	2,248.

SULPHUR IMPORTS

Country of Origin	*1956 Tons*	*Value per Ton* £ s.	*1955 Tons*	*Value per Ton* £ s.
U.S.A. ...	310,585	15 5	332,568	15 1
Mexico ...	41,978	14 6	25,271	13 19
Trinidad ...	633	15 6	1,575	14 15
Others ...	471	22 4	134	72 10
Total ...	353,657	15 3	359,548	15 0

PYRITES IMPORTS

Country of Origin	*1956 Tons*	*Value per Ton* £ s.	*1955 Tons*	*Value per Ton* £ s.
Cyprus ...	177,648	7 9	217,879	7 11
Canada ...	81,456	7 4	66,323	7 3
Sweden ...	10,750	7 0	4,849	7 7
Norway ...	8,101	8 3	14,464	7
Portugal ...	6,041	8 3	1,799	8
Spain ...	101,444	7 15	191,706	7 11
Total ...	385,440	7 10	497,020	7 10

Sweden

BRIMSTONE IMPORTS

Thousand Metric Tons

Country of Origin	*1950*	*1951*	*1952*	*1953*	*1954*	*1955*	*1956*
Norway	45.1	50.1	33.7	30.3	40.0	49.4	44.0
Chile	—	—	—	—	—	10.9	8.0
Italy	—	6.7	6.8	0.8	0.2	1.7	12.4
Mexico	—	—	0.2	—	—	6.7	11.1
U.S.A.	7.9	3.9	0.1	2.1	—	0.1	—
Others	—	0.5	—	0.8	2.7	2.8	3.4
Total	53.0	61.2	40.9	34.0	42.9	71.6	79.0

PYRITES

Metric Tons

	Exports	*Imports*	*Residues Exports*
1950	61,663	99,258	*
1951	4,100	72,781	248,918
1952	10,400	70,216	214,413
1953	12,000	66,672	*
1954	10,400	79,854	137,241
1955	15,800	123,056	159,679
1956	55,300	114,863	170,000 (est.)

Mexico

SULPHUR EXPORTS 1956

Metric Tons

	Pan-American Sulphur Co.	*Mexican Gulf Sulphur Co.*	*Gulf Sulphur Corporation*	*Total*
United States	175,460	19,473†	41,199	236,134*
United Kingdom	48,781	—	—	48,781
South Africa	42,981	—	—	42,981
France	59,013	—	—	59,613
Australia	21,798	10,059	9,400	41,257
Germany	51	—	—	51
Tunis	3,052	—	—	3,052
Netherlands	13,338	6,031	818	20,187
Belgium	10,413	1,288	—	11,701
Sweden	15,834	—	—	15,834
Canada	1,034	—	—	1,034
India	—	9,248	—	9,248
Total	391,755	46,099	51,417	489,273*

† Includes 8,241 tons shipped by the National Credit Bank for Agriculture and Livestock Credit.
* Includes 2 tons shipped by Azufre de Mexico as a sample.

United States

SULPHUR EXPORTS 1956

Canada	406,400	Algeria	19,335
Cuba	20,465	Tunisia	12,325
Guatemala	39	Egypt	3,048
Dominican Republic	238	Union of South Africa	71,500
Venezuela	1,483	Bahrein	794
Brazil	87,962	Iraq	2,300
Argentine	44,495	Iran	2,973
Paraguay	132	Saudi Arabia	225
Uraguay	2,739	Burma	100
United Kingdom	323,844	Hong Kong	500
Austria	21,216	India	66,081
Belgium	55,103	Japan	23,256
Finland	24,110	Korea	393
France	147,470	Pakistan	1,151
Greece	890	Australia	122,623
Spain	7,234	New Zealand	86,752
Canary Islands	3,000	Indonesia	6,380
Switzerland	43,213	Philippine Republic	1,128
West Germany	40,700		
Total ...	1,651,597 Tons		

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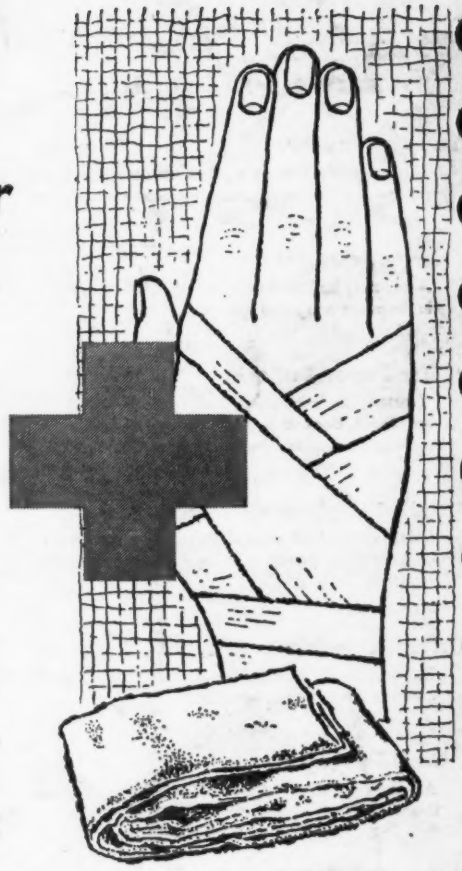

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